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LEE'S AMERICAN

AUTOMOBILE MANUAL

A HANDBOOK FOR ALL INTERESTED IN
HORSELESS VEHICLES

History of the Automobile — Internal Combustion
System—Steam-Power Vehicles—Electric Storage
Battery and Other Forms of Motor Power:
Compressed Air, Liquid Air, Carbonic Acid Gas, Steering Gears
—Rules and Regulations
in the operating of
Automobiles
Etc.

Edited by **ALFRED B. CHAMBERS, Ph. D.**

ILLUSTRATED

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LAIRD & LEE, PUBLISHERS

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CONTENTS

PAGE
Preface, ... 7
Facts and Figures concerning the Automobile and Motocycle during the year 1900, ... 9

PART I.

The Internal-Combustion Motor System.

CHAP. I. Invention and Principle of Internal-Combustion Motors, ... 29
II. Carbureter and Kindred Devices, . . . 51
III. The Question of Motor Speed, . . . 61
IV. Construction Features of American Gasoline Motor Vehicles—The Vallée System, 70
V. Ignition, Cooling and Exhaust, ... 92
VI. Modern Gasoline Motors—Governors, . 105
VII. Petroleum Motors and Vehicles, . . 126

PART II.

Steam Power Vehicles.

CHAP. VIII. Advantages and Disadvantages of Steam Automobiles in General — The Steam Renaissance in the United States, . . 135
IX. Description of Typical Steam Pleasure Carriage, ... 145
X. Variations in Steam Vehicle Construction — Freight Wagons and Omnibuses, . 157

PART III.

Electric Storage Battery Vehicles.

CHAP. XI. Storage Battery as a Power Source, . . . 165
XII. Construction Features of Typical Electric Vehicles, ... 171
XIII. Variations in Electric Vehicle Construction 191
XIV. Maintenance and Recharging of Storage Batteries, ... 205
XV. Notable Performances of Electric Vehicles, 216

PART IV.

Other Forms of Motor Power.

CHAP. XVI. Compressed Air, Liquid Air, Carbonic Acid Gas, ... 223
XVII. Combination Motors — Gasoline and Electricity — Gasoline and Compressed Air, 227

PART V.

Steering — Wheels — Tires, etc.

CHAP. XVIII. The Steering of the Automobile, . . . 233
XIX. Wheels, Tires, Differential Gears, Bearings, 245

PART VI.

Rules and Regulations Concerning the Operating of Automobiles.

CHAP. XX. The Chicago Ordinance, ... 261
XXI. The New York City Ordinance, ... 268
XXIII. Don'ts, ... 271
The Automobile Log, ... 273

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TABLE OF ILLUSTRATIONS

PAGE
Carriage invented by Cugnot 22
Symington Carriage....... 23
Gurney Stage-Coach...... 25
Daimler System..38, 40, 42, 54
Dion-Bouton Motor.....45, 84
Carbureter Jupiter........ 57
Henriod Distributer...... 59
Mueller System........... 71
Lewis Mechanism......... 73
Winton Phaeton.......... 75
3-cylinder Motor.......... 77
3-wheel Delivery Wagon. 78
Motor Tricycle.........81, 83
Motor Quadricycle......81, 83
Oakman Vehicle (Hertel).. 85
Vallée Vehicle............ 89
New Vallée Vehicle....... 91
Racing-Vehicle 101
Hydro-carbon Muffler..... 103
Two-cycle Motor.......... 107
Yale Motor............... 108
Wolverine Engine.....110, 111
Governor and Brake Mechanism................ 114
Marmonier Motor........ 117
Counter-Piston Controller, 119
Adjustment of Valve Spring Tension......... 122
Ignition Regulator....123, 125
Koch Motor...........128, 129
Secor Motor.............. 130
Roper Steam Bicycle..137, 139
Steam-Vehicle Boiler etc. 146, 147, 148, 149, 150
— Driving Gear......... 152
— Front view of Vehicle, 153
— Plan of Frame, etc... 154
— Water Tank and Connections 155
— Differential Gear, etc. 156
PAGE
Steam Vehicle Muffler.... 156
— Runabout 159
Marsh Wagon Boiler...... 160
— Control of Fuel Supply.................. 161
Morris & Salom Electobat 172
Electric Road-Wagon..... 177
— Victoria.............. 178
— Brougham 179
— Delivery Wagon...... 180
Single Motor Equipment.. 181
Double " " .. 181
Electric Motor............ 184
Driving Wheel and Gear. 185
Controller and Brake...186-87
Reversing Switch......... 188
Steering Apparatus.....189-90
Accumulators............. 190
Electric Phaeton.......... 191
Compensating Gear....... 193
Electric Stanhope........ 194
— Tally-Ho............. 195
— Phaetons...........197-98
— Runabout 199
— Brougham 200
Band Brake.............. 201
Steering Device.......202, 203
Electric Connections..... 206
— Hansom Cab.......... 207
Charging System.......... 213
Munson Phaeton.......... 229
Motor on Axle............ 230
Steering Diagrams..235, 239-43
Suspension Wheel........ 246
Compression Wheel...... 247
Pneumatic Tires........250-53
Inflating Cabinet 254, 256
Differential Gear......... 258
Operator's Badge...... .. 267

PREFACE

The progress recently made in the manufacture of self-propelled vehicles, sometimes called motocycles, and more commonly automobiles, has awakened great interest in America. France has been, to a great extent, the originator and, until recently, the producer of the most advanced and practical types on the market. Its magnificent roadways render possible one or two thousand mile trips covered in an incredibly short time. This contributed, of course, to make automobilism a most popular and inspiring sport. England, Germany, and even Italy, rapidly adopted the new method of locomotion, and, all over Europe, self-propelled vehicles of all sizes, models and prices are now being built.

The automobile movement in the United States is taking on a practical aspect, which makes it important that every vehicle user should investigate the subject, in order to ascertain if it contains a promise of greater economy, speed and efficiency, in this particular form of transportation, over common roads, for which, so far, horses and ordinary vehicles have been employed; or whether, perhaps, it simply offers a new and greater pleasure, and more rapid locomotion.

The road to a perfect understanding of the automobile problems and of the results accomplished by the American automobile industry up to date, seems to be barred to all but the few who have followed the movement from its very beginning and through all its phases.

Those who wish to be thoroughly posted regarding the early history of Automobiles and keep apace with the new improvements, will find "Lee's American Automobile Annual" complete and reliable.

As the title implies, we propose to publish this work annually, and it will be our aim to give the public the latest obtainable information on the subject.

That this Annual—the first of its kind published in this country—may prove helpful to all interested in this new mode of traveling, is our earnest desire.

THE PUBLISHERS.

Facts and Figures

Concerning the

Automobile and Motocycle

DURING THE YEAR 1900.

PARIS EXPOSITION AWARDS TO AMERICAN AUTOMOBILES.

The Columbia & Electric Vehicle Co. secured a grand prize, the highest award to any American motor-vehicle, although gold medals were given to the Locomobile Co. of America, the Riker Electric Vehicle Co. and the American Electric Vehicle Co., and silver medals to the Columbia & Electric Vehicle Co., the Electric Vehicle Co. and the Riker Electric Vehicle Co.

AUTOMOBILE CENSUS.

From Paris comes the following statistics: Automobiles registered in Paris, 3,701; in the suburbs of Paris, 1,219; in the rest of France, 2,445; in the whole of Germany, 1,427; in the whole of England, 530; in the United States, less than 300.

The accuracy of the figures is strongly questioned. as well it may, if the number of vehicles credited to the United States is a fair sample of the accuracy of the figures for vehicles in other countries. There are at least 150 individuals and firms in the United States that have built one or more vehicles, some of them a great many.

⁂

How much of the world has the automobile conquered? Five years ago there were not thirty practical horseless carriages in the world. One year ago there were not thirty in America. Yet last season Newport had an automobile parade in which nineteen carriages were in line, and there would have been fifty, could the manufacturers have supplied the orders. America leads, as might be expected, in the manufacture of the electric motor. That it would be no flight of fancy to call this the "automobile year" will appear from the fact that one American concern recently gave an order for 4,200 vehicles.

CITY REGULATIONS.

NEW YORK.—The Chief ot the Bureau of Combustibles has discovered that, according to Section 765, Chapter 378, of the laws of 1897, owners of automobiles which require the use of gasoline, are technically violating the law. So far he has done nothing more than to announce his discovery.

⁂

WASHINGTON, D. C.—The regulations in force here provide that no automobile or other horseless vehicle shall be propelled across any intersecting streets on whicn there are car tracks at a greater speed than six miles an hour, nor at a greater rate of speed between intersecting streets and avenues or cross streets on which there are no car tracks than twelve miles an hour. Outside the city limits the rate of speed must not exceed fifteen miles an hour.

The attorney for the District has rendered an opinion to the effect that separate licenses should be required for each automobile used for the transportation of passengers for hire, whether they be located upon a public stand or upon private property. He also held that a license should be required by the District Commissioners for each automobile used under contract with hotels, clubs, etc., or in the service of the United States, not, however, meaning such automobiles as are the property of the United States.

⁂

GERMANY.—The Cologne police have issued a set of very curious laws to regulate motor-car and motor-cycle traffic. Firstly, all vehicles must be adorned with a plate bearing the registered number of the car or cycle, then each rider or driver has to possess a police permit, thirdly, each vehicle has to have two brakes working entirely independent of each other; furthermore, the maximum speed permitted is twelve kilometers per hour and to crown all, every motor-car or wheel has to fitted with an apparatus preventing a transgression of the latter law. What is meant by this, after ordaining the presence of two brakes is inexplicable.

⁂

PARIS.—The prefect of police has established regulations preventing Parisian automobile cab-drivers from demanding extortionate rates. The maximum rate per hour is about fifty cents.

A great deal has been said about the automobile being a dangerous vehicle, and predictions are freely made that when the vehicles become more generally used accidents will be in great number. In France, where automobiles and motocycles are the vehicles of the masses, fewer accidents are recorded against the vehicle than any other form of locomotion. During the month of July sixty-eight persons were killed and 630 injured by horses, against three persons killed and twenty-five injured by motor vehicles.

⁂

BOSTON.—After considering the results of a public hearing held last summer, the Park Board has voted to grant the owners of automobiles further concessions by extending the time within which motor-vehicles shall be allowed to be driven in the park system an hour at each end. This means that automobiles may be run in the parks from 8;30 in the evening to 11:30 a. m. Still a tight rein is to be kept upon the auto by the board and if there is any tendency on the part of the chauffeurs to "cut loose" in the park system, the board will pull them up with a round turn. At present all vehicles may not exceed a rate of ten miles an hour in the parks, which is the legal limit all over the state.

AUTOS IN STRANGE PLACES.

CHINA.—James Dedric, a Californian, who has just returned from China, was in Bucyrus, O. arranging for the purchase of a number of ten-ton steel wagons and traction engines. When peace is fully re-established, he will establish a service across the desert in China, and enter active competition for carrying trade, which is now done by camels. The camel can carry only about 600 pounds and makes only twenty miles a day, while his wagons will carry ten tons each and make sixty miles. He has been over the ground thorougly and expects to have fifty engines and 3,000 wagons actively engaged within a year.

⁂

THE YOSEMITE.—Oliver Lippincott and E. Russell, on a Locomobile, were the first chauffeurs to penetrate the Yosemite. In it they climbed up 2,500 feet to Glacier Point, which is about 9,000 feet above sea level.

⁂

THE KLONDIKE.—E. Jean de Lamare, the Parisian who started from Skaguay with an automobile which he proposed to take to Dawson, returned in May, having failed in his attempt. He got into Atlin without great difficulty, but found it very difficult going down the Yukon. He was finally forced to abandon the trip, as the river was breaking up. De Lamare said he was in no way discouraged by his failure to reach Dawson, but he found the automobile he had was unsuited for the trip. The horsepower was not sufficient and the carriage was too low, touching the ground in rough places. He intends to have one specially constructed for these trips and believes it will revolutionize winter travel.

⁂

OZARK MOUNTAINS.—The automobile has superseded railroads and wagons in the affections of O. W. Ramsey and W. C. Wagner, travelling salesmen for St. Louis wholesale houses, whose route is through the mountainous section of Southern Missouri. They have recently returned from a trip of one month and 1,000 miles through the Ozarks and the surrounding country, having made the trip in a 2,300-pound automobile, which carried 1,000 pounds of baggage.

ARGENTINA.—The use of electric and gasoline motor cars in Buenos Ayres is developing rapidly, Not only heavy delivery wagons, but also luxurious carriages driven by oil or electricity are frequently to be met with on the streets of that city. The roads are gradually being improved, and a touring club has been formed with a view to watching over the interests of automobilism. Its first move will be to establish throughout all the provinces of the Republic, roads specially reserved for bicycles and light motor cars. These roads already radiate from Buenos Ayres for a distance of from sixty to seventy miles, and the work will be continued until a network of similar roads exist all over the country.

RAPID TRANSIT.

An automobile stage coach and mail line has been established in Speyer, Germany, and has carried 40,000 passengers in its five months of existence. Each coach will carry twenty-eight passengers, and be propelled by a benzine motor of ten horse power. The route is ten miles and the company has a contract with the government to carry the mails.

⁂

Millionaire Clarence W. Dolan, of Philadelphia, has a country place located at Towesdale, about ten miles above the city on the banks of the Delaware, and he needed a machine that could cover the distance between his home and his office in at least as good time as the suburban trains make. He ordered an electromobile of the highest possible travelling radius with the least possible weight. The vehicle, which was delivered to him at his Newport, (R. I.) cottage, was given several trial trips there. It is said to meet all requirements, the makers claiming that it can attain a speed of twenty-five miles an hour and maintain it for upwards of four hours on one charge of its batteries, and this despite the fact that it is considerably lighter than the majority of electric vehicles of lesser power. The body of Mr. Dolan's new machine is long and narrow, and set low, so as to offer very little wind resistance when running at speed.

Millionaire John Jacob Astor has organized an electric automobile omnibus service between Rhinecliff and Rhinebeck, to begin as soon as the hill at the Rhinecliff station is removed, contract for which has been awarded. This service will connect Rhinebeck with the New York Central railroad.

⁂

The New York Central Railroad has, for some months, been investigating motor vehicles with a view of establishing not only an automobile cab service from Ceutral Depot, New York, but auxiliary freight feeders to lines at various points from towns not connected with them.

NOVEL USES OF THE AUTO.

Congress was asked, this session. to make an appropriation of $2,000 for the purchase af a motor ambulance for the police department of the District of Columbia. The superintendent included this sum in his budget of estimates for the year and made a personal effort to secure it.

⁂

Automobile weddings have become so common as to attract no further attention, until Chicago came out with a hitherto unheard-of variety in the shape of a Chinese automobile wedding. Moy Ing, a prosperous Celestial restaurant keeper, took Sella Yoy to wife with the aid of an automobile, and now the pair are the wonder of Chinatown.

⁂

A well known Dresden dairy is sending out its milk, cream, butter, cheese and other products in automobiles; and its example will shortly be followed by Berlin's most extensive milk supply firm.

⁂

At the Paris Exposition, a dinner was given to over twenty thousand mayors of French cities and villages. This is probably the largest number of persons who were ever served at one time. The tables, if placed end to end, would have been four miles long. Several motor cars and four motor cycles were used to increase the rapidity of the service.

EXHIBITIONS AND PARADES.

COUNTY FAIRS.—Automobile exhibitions and speed contests were made the chief features at the county fairs all over the country last autumn. The demand for entries for the races was far beyond the supply. Numbers of chauffeurs with sporting blood arranged for tours of the country, taking in the races and paying their expenses from the prizes. For instance, L. R. Clinton and R. M. Whipple had no difficulty in securing engagements for their Locomobiles for these races and made a tour of the circuit. Whipple completed a tour of 1,200 miles through New York state and wrote to the Locomobile Co. of America concerning his complete satisfaction with the performance of his vehicle.

⁂

BOSTON.—On October 15, Boston saw its first general parade of automobiles. It was held under the management of the Twentieth Century Exposition, and there were nearly fifty vehicles of various makes in line. The procession passed over a route nearly five miles in length, and from first to last attracted the attention of great crowds of people all along the line. It was just about an hour passing over the route. The start was made from the Mechanics' Building at 10:15 o'clock. At the head were a score or more of private carriages, runabouts and stanhopes, and then came the mercantile vehicles, most of which were delivery wagon.

⁂

VIENNA.—An automobile exposition is to be held in Vienna this year, under the auspices of the Automobile Club of Austria and the patronage of the Archduke Francis-Salvator, who is himself a great lover of the sport. The exposition will be held from the 25th of May to the 6th of June, in the Prater, where a large space has been set apart for it. All kinds of automobile vehicles will be represented, including private carriages, towing machines, delivery wagons, motocycles, etc., besides the accessories and detached pieces, representing the advanced stage of development which the industry has reached in Austria. Foreign exhibitors will also be well represented, and the Automobile Club has extended a cordial invitation to all manufacturers. The club is taking measures to have the foreign products passed through the custom house free of duty on condition that they will be brought back directly after the exposition. It is expected that the German industry will show the advances it has recently made by a large number of exhibits.

ARMY AUTOMOBILES.

The Paris "Figaro" published an item to the effect that the Kaiser has offered a prize of 80,000 marks, or $20,000, for the best war automobile. Experiments conducted for some time past have shown such satifacfactory results that they induced the Kaiser to offer the prize, thus showing what importance he thinks the motor-vehicle will play in future wars.

⁂

The Scotte traction engine, drawing a train of cars on the road, is giving satisfaction in the French army. Twenty-five of these engines can provide an army of 60,000 men, sixty miles distant, with cartridges in eighteen hours. They can also transport fifty cannons of twenty-four tons each, a distance of ten miles in a single night. If the Prussians had had such engines in 1870 they would not have required to wait three and a half months before getting their guns into position for the siege of Paris. According to Moltke, they had to bring 960 wagons and over 2,000 horses from Metz for the purpose. A Scotte traction engine replaces thirty-two horses, and 200 or 300 of them would have enabled the Germans to commence bombarding Paris a few days after the investment began.

⁂

The German forces in China have been provided with a six-horse-power gasoline truck for use in operations there. The vehicle carries a direct-current dynamo and a wireless telegraphy outfit. The dynamo is driven by the gasoline engine, and will furnish the current for the telegraphic apparatus. The vertical wires of the telegraphic receivers are carried by balloons of eighteen cubic feet capacity. The order for the entire outfit was filled within twelve days.

A Berlin factory has furnished the German government with an automobile for the Chinese expedition. It carries the necessary material for wireless telegraphy operation. The motor used not only supplies power for the machine, but is utilized as well for driving a small dynamo generating the electrical current needed for the telegraph operations.

ALCOHOL-BURNING AUTOS.

More interest attaches to alcohol as a fuel in France than in America, owing to the fact that gasoline, or "essence" as it is called there, is higher priced than in this country, and because alcohol is cheaper. Experiments by French builders and chauffeurs have not shown that commercial alcohol gives as good results as gasoline, but, it has been found that a mixture of alcohol with certain hydrocarbon oils has resulted in producing a compound that is cheaper than gasoline and quite as efficient as fuel in internal combustion engines, volume for volume. Several firms offer liquid fuels, the formulæ of which they guard religiously. One, Lepretre, however, furnishes a compound composed of 50 per cent. of commercial alcohol mixed with 50 per cent. of benzine and obtains results quite as good as those obtained with the ordinary grade of gasoline and at a considerably less cost. The retail price of the mixture is 55 centimes per liter, as against 70 centimes for gasoline.

In the second criterion race which was run over a course from Paris to Rouen, there were fifty-two entries, fifty-one starters and thirty who finished. The winner turned up in Giraud on a Panhard. He was accompanied, as was each of the other contestants, by a judge appointed by the committee in charge of the event. The fuel used was the Lepretre compound.

A FEW 1900 RECORDS.

March 23, Rigal, the Frenchman, broke the 100-kilometer (62½ mile) road record, on the famous Etampes-Chartres course, making 1:30:49 1-5, as against the previous 1:46:12 3-5 and Beconnais' track record of 1:30:55 2-5. Rigal rode fifty kilometers (31 miles) in 43:50.

At Brussels, Belgium, in a contest for the flying and standing start kilometer, Jenatzy, with his three-horse power gasoline vehicle covered the flying start kilometer in 38 1-5 seconds, a speed of ninety-four kilometers (50½ miles) to the hour; the former record belonged to Lemaitre, in 47 4-5. Another Belgian, Miesse, rode the same distance in a steam vehicle in 48 4-5 seconds, which is also a world's record.

⁂

Will forty miles ever be covered in one hour's ride on a bicycle? Will O. Stinson has demonstrated that the distance could be made. The plucky Cambridge rider had 330 yards to spare, when the hour was done. This feat was accomplished, Oct. 25, on the Brockton, Mass. track, at which place Stinton and his retinue had been camping for a week.

Stinson's bicycle was an Orient Leader, and for pace he followed an Orient-Aster motor-tandem, and it was to the remarkable way in which this pacing machine sped about the track that he was able to make the coveted distance. For the full hour it ran without a skip or break, keeping up an even speed, which was so necessary to the success of the undertaking.

Stinson has proven himself the best man in this country in every mile up to 40, with the one exception of the mile, which was also secured on an Orient Leader by Harry Elkes.

AUTOS ON RUNNERS.

The H. C. Akeley Lumber Co., of Minnesota. was among the first to give the automobile sled a practical test and results satisfied them that the idea was worth following up. In the winter of 1899-1900 the company used a rather crude affair built in the woods, but strong enough to do good work. During the summer a more powerful and better-built locomobile sled was constructed at a city machine shop, and since the weather became cold enough for ice roads, this machine has been doing the work of from ten to fifteen teams. It can haul fifteen sleds of logs. In some cases such a load has been hauled seven miles. In moderate weather this size train can be hauled successfully. In weather at zero and below the train consists of about ten cars, for the freezing of the runners to the ice while the train is being loaded prevents the starting of more than ten sleds at once. This train has drawn last winter 5,000,000 feet of logs, travelling six miles an hour light, and five miles loaded.

These sleds are coupled together as cars are, and track perfectly, never getting out of line with the runners of the engine. The road is a regular ice road, rutted for the runners as for team hauling.

ROYAL AUTO DRIVERS.

The Kaiser has suddenly discovered that there are different uses for a motor-car than military ones only and drove to the Wilhelmshohe station on August 22 in a very fine four-seater to meet his uncle, the (then) Prince of Wales. This car is reported to be one of the fastest vehicles in Germany, capable of going 95 kilometers (59 miles) an hour; beautifully upholstered, as well it may be, as the price is 32,000 marks. It is concluded from its price that it is a French car, as those manufactured in Germany are not so expensive.

⁂

King Alexander of Servia is the latest royal patron of the automobile, and is at present putting in all of his spare time scorching up and down the hilly roads in the neighborhood of Belgrade, his capital at breakneck speed.

AUTO-PARAGRAPHS.

People and papers have called the automobile by all sorts of long and short names and concocted all manner of abbreviations of the word automobile. The latest, shortest and nerviest is that employed by a heading writer on a Philadelphia daily. He does it thus: "O."

⁂

The American Steel & Wire Co. and the Republic Iron & Steel Co., two mammoth corporations, both have their eyes on the automobile business and are making preparations to furnish the various structural iron used in the construction of motor vehicles.

The Cannstatt-Daimler works, of Cannstatt, Germany, have recently put out a new motor of no less than thirty-two horsepower. It will weigh a trifle under 300 pounds or between nine and ten pounds per horsepower. It is said that it is largely constructed of a metal which costs more than $3 a pound.

⁂

An Australian millionaire owns what is said to be the heaviest motor-vehicle in the world. It weighs fourteen tons and is run by a gasoline motor of seventy-five-horse power. This enormous vehicle, which is capable of a speed, when needed, of eight miles an hour, is employed to carry freight to and from a gold mine situated 372 miles in the interior of the country.

⁂

According to rumor, L. D. Munger, of the United States, received for his motor vehicle tire, $288,000 in stock in the concern organized by the Flint interests and in addition to this an annual salary to run for five years of $15,000 with $100 a week expenses and 7½ per cent. on the gross sales. Munger still owns the foreign patents on his automobile tire and is said to have been offered $50,000 for a one-quarter interest in the French rights.

⁂

A new automobile has been invented by a Russian named Hutal Serky, who has discovered a new system of locomotion based on the use of a certain kind of salt, the composition of which is his secret. Two pounds of this salt placed in the box of the automobile, and subjected to a certain heat, forms a gas which puts a cylinder in movement. The automobiles that were tried in Moscow produced the best results. The Emperor of Russia, who takes great interest in the matter has sent Serky to Paris to find out what the Frencn experts think the invention is worth. The Russian press is of the opinion that it will cause a great revolution in the trade.

Lee's Automobile Annual

THE GENESIS OF THE AUTOMOBILE

Just as the name "Automobile," although a most awkward and irregular combination of a Greek word and a Latin word, has come to stay in spite of many-voiced protestations, just so is the self-propelled vehicle which is designated under this name destined to become one of the permanent features of Twentieth Century out-door life. And yet, new though it seems to be, and is doubtless believed to be, by the majority, the automobile has a past, a history, a "Genesis," and its old records possess an interest of their own, even for those who are simply attracted to the more modern types of horseless carriages. Let us, therefore, look over this history with a rapid pen and a retrospective memory.

This record goes back, they say, to the old Pharaohs, and many a learned student of early Egyptian architecture has discovered among the curious carvings so plentiful in the Land of the Pyramids, reproductions of strange vehicles that seem to have moved about without apparent means of locomotion. So much for ancient history. It will be a long jump from King Rameses to the XVIIIth century of the Christian Era and to artillery captain Nicolas Cugnot, of the French army, who, in 1763, presented to the government of King Louis XV a complete working-model of a steam-actuated automobile. From this crude attempt date, in reality, the studies and efforts toward the building and operating of self-propelled vehicles. In the Conservatory of Arts and Trades, in Paris, is preserved the second and perfected steam-wagon of Captain Cugnot, built to be used as a gun-and-ammunition carriage; it is dated 1769, and was operated successfully for some time. (Fig. 6.) It is indeed the precursor of our modern railroad engine, as much and perhaps

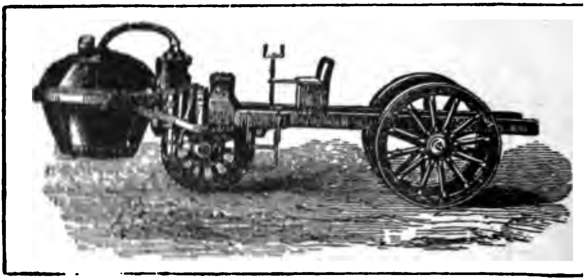


Fig. 6. The Steam-Artillery Carriage Invented by Captain Nicolas Cugnot (1769).

more than it is the original type of the present automobile.

Two other Frenchmen, Dallery and Séguin, followed in the footsteps of Cugnot, and went so far as to construct a steam-carriage with a tubular boiler; they date back to 1790; while James Watt's famous patent was taken in 1786, and Symington, also an Englishman, placed on the road, in the same year, a steam carriage, well equipped and fairly reliable in its operations. [Fig. 00.]

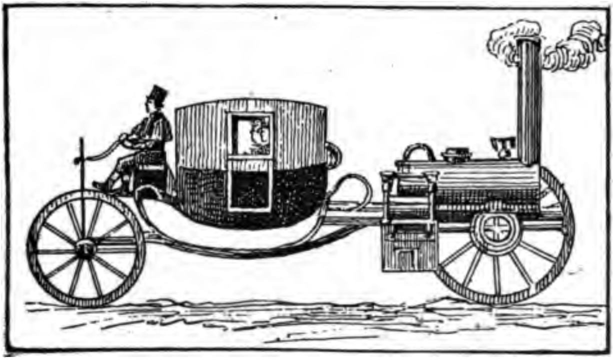


Fig. 00. The Symington Steam Carriage (1786).

In 1801, Captain Richard Trevithick, of England, built and operated successfully a full-size steam-coach, but failed to attract capital to his invention, and soon abandoned it as unprofitable.

It was also in 1786 that American ingenuity turned its attention for the first time in the direction of self-propelled vehicles. Oliver Evans applied on that date for a patent to protect his designs of a steam-wagon; while, in 1790, Nathan Read did actually receive a United States patent on a double-acting steam-engine; he constructed a small model, but no full-sized carriage.

As soon as the nineteenth century had left behind it the troubled years of Napoleonic greatness and fall, and turned to its task of dazzling the world by the wealth of its inventive genius, the improvement in the means of transportation became one of the absorbing problems of the hour. For three years (1822-25) a large, commodious coach, actuated by steam, ran regular trips between the Bank of England and the London suburb of Paddington. It had been built by a scientist of no mean ability, Sir Goldsworthy Gurney, and was later much improved by one of his pupils, Mr. John Squire, assisted by Colonel Macerone, a distinguished Italian engineer. [Fig. 000.] The average speed reached, even at that time, eleven miles an hour, and steep grades were taken with ease and fair speed. Between 1828 and 1833, a number of "Gurney coaches" were built and operated in England. Had not the advent of the railroad absorbed the attention of public and capitalists, no one can tell what a revolution these horseless coaches might have realized in the transportation—upon the Queen's highway—of both passengers and freight. As it was, the smoothness of the rails got the best of the yet so imperfect automobile, and the envious animosity of stage-coach owners succeeded in wiping away even the remembrance of these first and highly-laudable efforts.

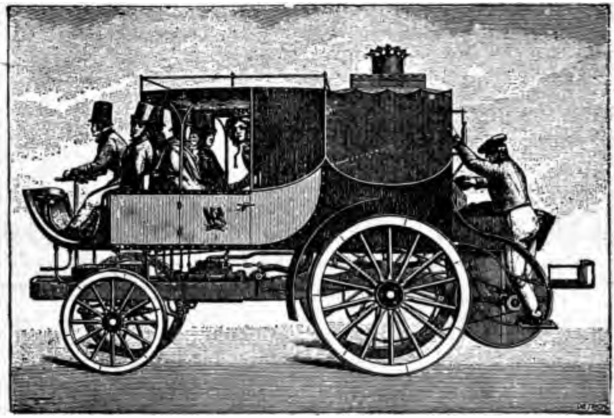


Fig. 000. The Gurney Stage Coach perfected by Macerone & Squire (1823-28).

There is no doubt that the recent extraordinary success of the bicycle—especially the safety—contributed to a renewed interest being manifested in the construction of self-propelled vehicles. To the French—the descendants of Captain Cugnot—is due the first energetic impulsion given in the right direction. In 1890, a slow but otherwise satisfactory vehicle, built by Serpollet and Archdeacon, made a journey between Paris and Lyons; its motive power was steam.

Four years later, thanks to the popular excitement created by the famous Petit Journal, the first automobile race of importance brought forth a number of competitors. The question of the relative merits of steam and petroleum (hydrocarbon system) was practically settled on this momentous occasion; for, although Count de Dion's steam-carriage reached the goal (Rouen) in excellent condition and ahead of its competitors, the first prize was divided between him and Messrs. Levassor and Peugeot, builders of petroleum automobiles. In 1895, the hydro-carbon motor achieved a signal victory in the great race between Paris and Bordeaux and return (750 miles), accomplishing this feat without a break and in less than forty-nine hours, beating its rivals by several hours.

Since that great day, automobilism has implanted itself in Europe as the locomotive system of the future, for all such purposes as demand freedom of circulation on the high roads and a rapidity compatible with public safety. The successful efforts of American manufacturers to create in this country a large industry of automobile-building needs no special commendation in this introduction; they are explained in full through the pages of this volume.

Part I

The Internal-Combustion Motor System

CHAPTER I

INVENTION AND PRINCIPLE OF INTERNAL-COMBUSTION MOTORS

By internal-combustion motors is understood that kind of motor in which power is produced by the expansion of gases generated by the combustion of hydro-carbon gas which is mixed with air and ignited within the confines of a cylinder in which works a piston.

In most motors of this type there is only one piston working in the cylinder, the latter being closed at one end, but provided with valve channels for the admission of the gas mixture. In certain motors of recent invention both ends of the cylinder are open and two pistons work in each cylinder, in opposite directions.

Various theories have found advocates in regard to the chemical and mechanical action that takes place when a mixture of hydro-carbon gases and atmospheric air is ignited, but it is sufficient for the understanding of all the workings of internal-combustion motors to consider that the gas acts as a fuel which is very readily fired when mixed with air, because the air supplies the necessary oxygen for almost instantaneous combustion, while the unused oxygen of the air together with the other constituents of atmospheric air are simply expanded by the heat, and by their expansion drive the piston.

From this point of view the internal-combustion motor is, then, essentially a hot-air engine in which the air is heated, immediately before it is ready to be used, by the intermittent combustion of hydro-carbon gas. The air, when heated, is in intimate and minute intermixture with the burning fuel, and no time is given the air to cool before the expansion is utilized for motor work. Hence the great economy of the internal-combustion system compared with other less direct systems of converting the latent heat of carbons or hydro-carbons into motive energy.

On the other hand, the practical difficulties in controlling and regulating the power so cheaply and simply developed, are much greater than those attending the use of steam or electric current, and have so far been only partly overcome.

The efficiency of the internal-combustion motor depends upon a number of factors, among which the following may be mentioned as the most important: (1) Regulation of proportions between gas and air in the mixture; (2) timing of ignition and compression of charge before ignition takes place; (3) caloric value of the gas used. Hereto should be added (4) general suitability of the motor for the special work for which it is intended, but for this requirement no general rules may be laid down. It is self-evident, however, that the motor construction which will suit such work as operating a printing press or a metal-stamping machine, both requiring intermittent developments of power, may be much simpler than that construction required for motor vehicle work, as for the latter the spasmodic work of the gas engine piston must be first equalized into motion of perfect uniformity at any given time, and yet must also be made adaptable to great variations of load and other factors in the conditions of travel. In the industrial uses of the internal-combustion motor it has, therefore, also been noticed that the first application was just for such purposes as above mentioned, for which the intermittency of the power was an advantage. Subsequently, it was taken in use for other industrial purposes for which economy and readiness of the power was of supreme importance, the intermittency being reduced by the use of heavy fly wheels; but only lately has it been so developed as to encroach seriously upon the domain of the steam engine for general manufacturing purposes on a large scale.

It will be seen later that this development is chiefly due to the adoption of the two or three cylinder type of motor, and to improved systems for effecting ignition.

Its application to the propulsion of vehicles is by far the most severe test of its adaptability to which it has been put, and has given the impulse to more study of its peculiarities and more improvements in its construction than any previous use of it.

The hydro-carbons that have been employed for internal-combustion motors are illuminating gas, gasoline, benzine, petroleum, alcohol and acetylene gas; the latter two only to a very limited extent. When illuminating gas is employed the motor is usually termed a gas engine, but this form is available only for stationary work on account of the impracticability of carrying sufficient stores of fuel unless the gas is drawn from a liquid supply.

Gasoline is the most commonly employed liquid hydro-carbon, being especially adapted for vehicle purposes by the readiness with which it vaporizes, the high value for heating purposes of its vapors and the extensive production and use of it for domestic purposes, making it readily obtainable in nearly all localities. Oils which are chemically almost identical with gasoline, being composed of hydrogen and carbon, though produced by different processes of refinery, are known under different names in the various countries, such as essence, petrole, petrol spirit, benzine, but their usefulness as a fuel for internal-combustion engines depends, in all of them, on their specific gravity, which determines the temperature at which they begin to give off inflammable vapors. This temperature is termed the "flashing point." In practice kerosene is graded by the Baumé scale, which indicates the greatest density by the lowest number, and the gasolines and naphthas are designated by their boiling point and specific gravity. The kerosenes grade from 48° to 43° Baumé and should not flash below 110° Fahr. The gasolines grade from 80° to 67° Baumé, with specific gravity from 0.65 to 0.71. Still more volatile than the gasolines are the naphthas. The flashing point in all hydro-carbons varies somewhat with the barometer.

Petroleum or kerosene ("heavy oil") is considered preferable to gasoline because it may be handled more carelessly and may be bought in any country store. It is used in several modern motors for stationary work, but as yet not extensively for motor vehicle work on account of the difficulty in vaporizing it by the ready means that suffice with gasoline, and the resulting slowness in starting the vehicle after the motor has been at rest for some time.

Alcohol (wood alcohol) has been used with considerable success in certain French and German automobiles, and might be used more extensively if it were not that most governments impose a tax on its production that raises its cost to the consumer above that of gasoline.

Acetylene gas, produced by the action of water on carbon and lime, fused together (calcium carbide), has not so far been successfully employed for motors, principally because it leaves a considerable residue after combustion.

Internal-combustion motors are frequently termed hydro-carbon motors, and the specific names, gas motor, gasoline motor, petroleum or kerosene motor, are also used, so as to denote the fuel employed, it being understood that the main principle is that of internal combustion. They are, all of them, also sometimes called explosion engines or explosion motors, because the combustion of the gas mixture (explosive mixture) takes place so rapidly that a distinct report or explosion is heard. In the small cylinders used for motor vehicles this report is not very loud, but has yet caused this style of vehicle to be known in France as "teuf-teuf" (pronounced "tuf-tuf"). The more sibilant sound produced when the charge of the cylinder after each explosion is exhausted into the atmosphere is in all modern gasoline motor vehicles suppressed by means of a muffler device, which, however, consumes part of the power derived from the explosion, and is, therefore, frequently left off at motor vehicle and motocycle races in order to increase the speed.

Hydro-carbon motors are spoken of as being Ottocycle or four-cycle motors, or else two-cycle motors, besides other special "cycles" of lesser frequency. The "cycle" referred to is the cycle or repetition, during the work of the motor, of a certain fixed succession in the functions performed by means of the piston strokes. These functions are as follows: First, to draw the explosive mixture into the cylinder; second, to compress this mixture; third, to fire the mixture and produce the explosion; and fourth, to expel the burnt gases and products of combustion.

When it requires four piston strokes to perform these functions the motor is said to be of the Ottocycle or four-cycle type, which is the one most commonly employed. If they are performed during two strokes of the piston the motor is a two-cycle motor. With the latter it has until recently been found very difficult to prevent premature explosion of the gas mixture, because inner walls of the cylinder and admission valve become heated to a temperature ranging from 2,000 to 2,700 degrees Fahr. at each explosion, and do not get time to cool down below the temperature (about 1,700 degrees) required for igniting the gas mixture before a new charge of the latter is introduced. With the Otto cycle, having twice the number of piston strokes for each explosion, this difficulty does not exist to the same degree, but, on the other hand, the Ottocycle motors have only one power stroke out of four strokes, so that they depend largely on a fly-wheel to keep them in motion when working slowly near the limit of their capacity. In motor vehicles, where a large fly-wheel is impracticable, this drawback to the most commonly employed type of gasoline motor is overcome by using two, three or four cylinders with the pistons working on the same crank shaft, 180, 120 or 90 degrees apart, so that the explosion in any cylinder helps in performing induction, compression and exhaust strokes in the others.

Etienne Lenoir, a self-taught French engineer of great versatility, invented a gas engine in 1859, but the theory of the modern gas engine dates from 1862, when Beau de Rochas, another French engineer, formulated the theory of the operations to be carried out.

Four conditions were laid down by him as essential to efficiency. First, the largest cylindrical volume with the smallest circumferential surface; second, the maximum speed of piston; third, the greatest possible expansion; fourth, the highest pressure at the beginning of the expansion. To obtain these results he considered it necessary to use one cylinder only. First, that it might be as large as possible; and, second, to reduce the piston friction. In this cylinder he proposed to use the following cycle in four consecutive piston strokes. First, the drawing in of the charge of gas and air; second, the compression of the gas and air; third, the ignition at the dead point with subsequent explosion and expansion; fourth, the discharge of the products of combustion from the cylinder. This cycle, known as the Beau de Rochas cycle, is now used in almost all gas motors; but, although published in 1862, it was not until 1876 that Otto produced a practical engine (exhibited in 1878 at the Paris exposition), which utilized the cycle of Beau de Rochas.

Before entering upon a description of the details in modern hydro-carbon motors (pertaining to the regulation of the gas mixture when drawn from gasoline or petroleum, the various systems of ignition, the cooling of the cylinders, and the transmission and running gears of hydro-carbon motor vehicles), a description of one or two of the best known types of motors may be given as a foundation for the better understanding of all other styles.

Figs. 1, 2 and 3 illustrate an early style of a motor designed by Gottlieb Daimler, of Cannstatt, Germany. (Daimler died March 6, 1900, sixty-six years old. He was known in Paris and to the engineers' profession generally as "the father ot the automobile.")

G. Daimler and Carl Benz (the latter still living at Mannheim, Germany) were the first who applied the gasoline engine to the driving of vehicles. They produced in 1886 a motor tricycle and a four-wheeled motor carriage, respectively. The motors used in these have become the prototypes for the motors used to-day, not only in vehicles manufactured at the Daimler works and the Benz works in Germany, but also for many of the designs adopted in France and England. The Panhard-Levassor style of vehicle which has won nearly all of the French long-distance races is equipped with the Daimler-Phœnix motor, which is an outgrowth of the first Daimler motor and resulted from

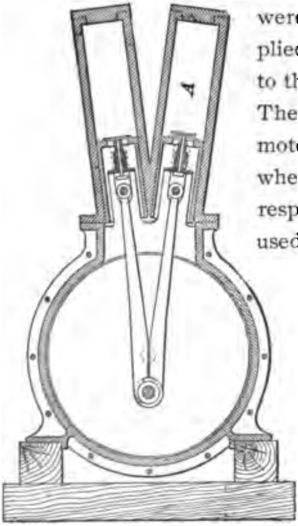


Fig. 1. Daimler System.

the co-operation in Paris between Daimler and Levassor. In the United States the Daimler motors have been used for marine craft, but not so far as known for motor vehicles, although Daimler works in England and Germany turn out not only pleasure vehicles but also the best-known of the heavy freight wagons that are operated with internal-combustion engines.

The motor illustrated is of the four-cycle, two-cylinder type, so that an impulse is obtained for each revolution of the crank-shaft. The forward part of the cylinder, instead of being thrown open to the atmosphere, opens into a compartment which also incloses the crank-shaft and fly-wheels. This compartment is air-tight, and is provided with an automatic admission valve. All the valves on the Daimler motor are what are known as poppet valves, that is, they are closed automatically by a spring. The operation of the motor is as follows:

We will assume that a charge of air and gas has been admitted to cylinder A (Fig. 1), and that the piston has been propelled forward by the pressure generated by the explosion. In traveling toward the crank-shaft compartment, air, or a mixture of air and gas, is compressed in the compartment, and as the piston reaches the limit of its forward stroke, a valve in the piston is automatically opened, and this compressed charge is allowed to enter the cylinder as soon as the pressure behind the piston is less than in the inclosed compartment. At this instant, the exhaust valve has been opened, so that there is a clear outlet from the cylinder into the exhaust. The compressed air from the compartment, therefore, sweeps through the cylinder, and the products of combustion are crowded out together with the compressed air, as the piston returns to its original position. As it again starts forward, owing to the impetus of the fly-wheel resulting from its former stroke, a partial vacuum is formed in the cylinder A, and a charge of air and gas is allowed to enter through the valve D (Fig. 3). This mixture is to be of fixed proportions, and when the valve in the piston is again opened the charge of air, or mixture of air and gas from the closed compartment,

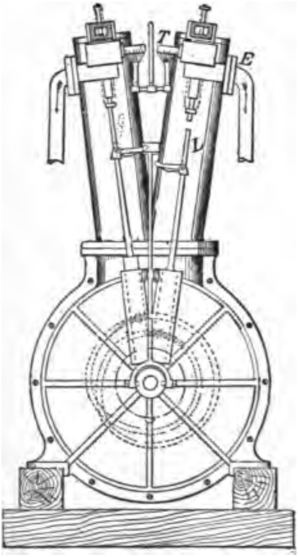


Fig. 2. Daimler System.

mixes with the charge admitted by the valve D; the pressure from both equalize in the cylinder, the proportions of the change being such as to produce the desired mixture. The piston now returns and compresses the charge, which is ignited by the heated tube T (Fig. 2), when the dead point is reached, and the piston is thus given another impetus forward.

The fly-wheel is shown in the side elevation in Fig. 2. This wheel has two circular grooves connecting with each other. During one revolution, a sliding block connected to the valve rods (Figs. 2 and 3) is arranged to travel in the outer circle and then in the inner circle, at every revolution changing from one to the other. By this means, the valve rod is brought in contact with the exhaust valve E, and this valve is raised from its seat, allowing the products of combustion to escape. Upon the valve rod being lowered, a retractile spring returns the poppet valve to its seat. The admission of the air and gas is automatic, as the suction in the cylinder allows the valve D to open inward and the gas and air to be admitted to the cylinder, the valve returning to its seat as soon as the piston starts to compress the charge.

Ignition is effected by means of a hot tube; a system which is still preferred by many, although it is now fast giving way to improved methods of igniting by electric spark. A pilot light or burner maintains the tube T at a suitable temperature, and, in order to ignite the charge at the proper time, the proportion of air and gas during the latter part of the admission period is varied. That is, the charge is more or less diluted with air, so that when the piston returns and compresses the charge into the ignition tube, the actual time at which the ignition takes place depends upon the quality of the charge which is in the tube, and the quality is regulated by a small valve in the gas pipe.

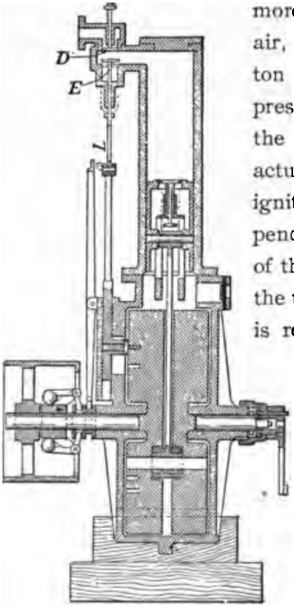


Fig. 3. Daimler System.

The speed of the engine is controlled by a governor acting upon the exhaust valve; it prevents the rod from lifting the exhaust valve from its seat, and thus maintains in the cylinder a pressure that does not allow a fresh charge being admitted except at intervals consistent with the speed desired.

The Daimler motor was first patented in this country in August, 1886. This early patent covers the grooved cam for controlling the action of the exhaust valve, and the specification describes a method of circulating air on the outside of the cylinder in order to prevent the cylinder from becoming overheated. The second patent, granted in September, 1886, covers the method of ignition by varying the mixture of the gas during the latter part of the admission period; also the feature of governing the speed of the engine by preventing the exhaust from operating. This patent is the one which covers the method of admission of the charge of air, or combustible mixture, the system of expelling the products of combustion and thus clearing the cylinders, also the admission of part of the charge, either as a combustible mixture or as air, by means of the valve in the piston. The third patent, granted in 1889, protects the feature of the two cylinders connected with one crank shaft and the compressing of the air or mixture into one compartment. In the smaller Daimler engines no water jacket is used.

Among the motors which are in use abroad for light motor vehicles, motor tricycles and for pacing machines on the bicycle race tracks, those of the De-Dion-Bouton system have gained the greatest celebrity, being manufactured early and on a large scale, and are now being fitted to similar vehicles in this country.

Fig. 4 shows a diagram by which the operation of these motors may be readily understood, the drawing showing all the parts plainly, but not exactly in the manner in which they are arranged in the motor in reality.

To the left is the vaporizing chamber of the carbureter, in which the gasoline contained in the lower half is brought into contact with the air entering by the tube A, and made to pass between the horizontal plate B and the surface of the liquid; the carbureted air then rises, as shown by the arrows, and enters the double valve C, shown below in detail, by which it is mixed with an additional quantity of air, which enters by the orifice D, at the top; the mixture then passes to the motor by means of the tube E. The admixture of air is regulated by the handle on the left, and the supply of gas by that on the right. The float F serves to indicate the level of the gasoline in the carbureter by means of a rod which passes through the tube of admission; and the tube itself is arranged to slide up and down in order to maintain a constant difference between the horizontal plate and the surface of the liquid, this plate being attached to the lower end of the tube.

To obtain uniform results from the explosive mixture, the temperature of the liquid gasoline should be kept as uniform as possible.

In order to avoid the cooling of the gasoline by evaporation, it is warmed by means of the tube G, through which passes a portion of the hot gas escaping from the motor. By this means a nearly constant temperature is obtained for a given speed of the motor.

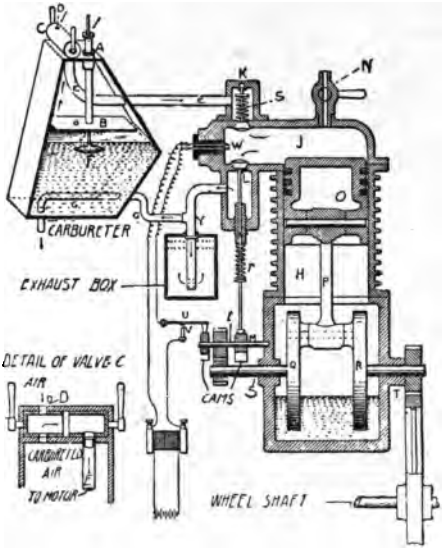


Fig. 4. Diagram of the Dion-Bouton Motor.

The cylinder H of the motor is of cast steel, with projecting flanges which serve to increase its radiating surface and prevent overheating; above is the chamber J, in which the explosion of the gas takes place; at the top of the chamber is the valve K, which admits the gas coming from the carbureter; the valve is normally closed by means of the spring S, whose pressure is regulated so as to allow the valve to open upon the descent of the piston. Opposite is the exhaust valve L, which permits the waste gases to escape after the explosion; to the valve L is attached a rod which passes through the cover of the exhaust chamber and engages with a cam, M, which, by pushing up the rod, opens the valve at the proper instant, this valve being normally closed by the spring r.

At W is shown the igniter, consisting of two copper rods passing through an insulating bushing, and so arranged as to allow a spark from the induction coil to pass to the interior of the chamber for the ignition of the gas. The piston O is a hollow steel casting, provided with three packing rings, and carrying the wrist-pin. The piston is connected with the inclosed fly-wheels Q and R, and with the shafts S and T, by means of the piston-rod P. The shaft S carries a pinion which engages with another of twice its diameter, operating the small shaft above, t, which carries two cams; the cam to the right serves to open the exhaust valve once in every two revolutions, while that to the left acts upon the lever arm U, carrying the contact V of the induction coil, by means of which a spark is caused to pass at W, thus igniting the gas contained in the chamber of the motor. This induction coil is operated by four dry electric piles.

When the piston descends, it produces a vacuum in the top chamber, by the action of which the valve K opens, admitting the detonating mixture from the carbureter; when the piston rises, it compresses this gas, and the valve of admission closes. At the instant of the second descent of the piston the cam actuates the lever, making contact with the induction coil, upon which a spark passes, causing an explosion of the gas, which pushes the piston with sufficient force to cause it to pass twice through the same position; when the piston rises after its descent, it compresses the residual gases of explosion, and at this instant the cam M lifts the exhaust valve, and the gas leaves the motor by the exhaust pipe Y. When the piston redescends, this valve closes and the upper valve opens, as before, to admit a fresh supply of gas; and so on.

It is to be noted that the above-described De Dion-Bouton motor is provided with a special combustion chamber extending to one side of the cylinder, while in most other motors the upper end of the cylinder is utilized for combustion. By this irregular shape of the chamber J, an enlarged radiating surface is obtained which serves to cool the combustion chamber more quickly after each explosion, and thereby prevents premature explosion of a charge, a provision which is of considerable importance in small motors designed to operate with great piston speed and, consequently, rapid succession of explosions, and yet without utilizing water for cooling purposes.

The stop-cock N, at the top of the combustion chamber, is designed to be opened when the motor is started, if the operator desires to make the start easier. All internal-combustion motors must be started by hand power in order to draw in the first charge of gas mixture and compress the same before the first explosion stroke can be made; and for this purpose a crank is usually provided with gasoline motor vehicles, by which the motor shaft may be given the initial rotations before the motor mechanism is connected with the driving gear of the vehicle. In some modern vehicles the driver may perform this hand work by means of a lever operated from his seat, but ordinarily it is done while standing on the ground beside the vehicle; and the awkwardness of this starting method has so far been one of the most serious inelegancies of hydro-carbon motor vehicles. With large cylinders the exertion required for the initial turning of the motor shaft is considerable, on account of the resistance that the explosive mixture offers against compression.

When the stop-cock N in the De Dion-Bouton motor is opened this resistance is relieved while the combustion chamber yet retains a considerable portion of the gas (on account of its special form), and the explosion which follows, while weakened, is generally sufficient to carry the fly-wheel around and help overcome the resistance at the next compression stroke; whereafter the cock N may be closed, and the motor will continue to work from its own energy.

In small vehicles, such as motor bicycles and tricycles equipped with pedals by which the rider may assist propulsion, the use of a starting-crank is, of course, superfluous, as the rider can impart the first impulse by means of the pedals, but, as most riders of these machines prefer not to use the pedals except in emergencies, the start is in reality usually made by pushing the machine along for a short distance before mounting; or having another person push it.

It is also a favorite method with larger motor vehicles to have them started by a person on the outside, the driver in that case connecting the motor and driving mechanism first, so that the rotation of the wheels will be transmitted to the motor shaft. But with freight wagons and heavy loads, that may not be easily pushed, the driver is, as a rule, compelled to start the motor going first and connect the transmission gear afterwards; a fact which renders it necessary to employ some method of connecting the transmission gear, as by friction clutches or belt, which will not be easily broken when the connection is being effected. With a perfectly positive gear connection, there would be considerable danger of breakage from the shock received from the motor in motion, especially when the start is uphill or otherwise presents unusual resistance.

CHAPTER II

CARBURETERS AND KINDRED DEVICES FOR MIXING AIR AND VAPOR.

The reliability of gasoline motor vehicles depends very much upon control of the fuel supply. Each power stroke of a three-cylinder motor in a vehicle that weighs about 800 pounds with its load, and is driven over a good road at a speed of about ten miles per hour, requires only about one-third of a drop of gasoline to be evaporated and mixed with air. If more gasoline is used than required the quality of the mixture is changed, as the suction stroke of the piston can only draw in one cylinderful, and if there is an excess of vapor there must be a shortage of air.

The most violent explosion is produced by a proportion of one volume of vapor to eleven of air, but it has been found the best practice to make the proportion of air larger, and thereby make the power more tractable.

As in steam engines power and speed are regulated by the amount of steam admitted to the cylinders, so it is the modern tendency to control power and speed in gasoline engines by the quality of the explosive mixture; or, as in one case described in the chapter on Modern Motors, by its quantity.

Dealing with very small quantities of gasoline for each induction stroke, it has, however, been found exceedingly difficult, in the past, to obtain uniform results if the variations in speed of the vehicle were allowed to interfere with the adjustments by which the generation and admission of gas mixture were regulated.

If the piston speed were reduced at the same time as the speed of the vehicle slackened, for example, on account of a grade in the road, the induction stroke would be slower, and, with the devices commonly in use, the amount of vapor in the mixture would be reduced. By this the force of the subsequent explosion would be changed (either weakened or strengthened, according to circumstances), and if weakened the speed of the vehicle would be still more reduced; the next explosion would be still weaker, and so on until the vehicle would come to a standstill.

This is only one of the many complications that may arise if construction of a vehicle is such that the quality of the gas charge must depend upon the speed of the suction stroke of the piston—besides temperature and other minor variable factors—and the speed of this stroke varies with the speed of the vehicle.

In attempting to solve these difficulties, French motor vehicle engineers have generally adopted a construction by which the motor speed remains nearly constant, the gasoline in the vapor generator or "carbureter" being kept as nearly as possible at a uniform temperature, while the speed changes of the vehicle are effected by means of variable-speed gearing or by tightening or loosening a driving-belt or friction-clutch. Their example has been extensively followed in this country; but lately another method has been gaining ground. This consists in measuring the liquid gasoline to be used for each explosion by means of a diminutive pump, actuated by a cam or gear wheel from the motor shaft and under control of a hand-actuated lever, and depositing this fraction of a drop of gasoline in the constricted portion of the duct through which the atmospheric air is taken into the cylinder; the proportions of air and gasoline being so adjusted that the gasoline deposit under all circumstances will be fully evaporated and absorbed in the air current.

Of the two methods the latter leads to control of vehicle speed by regulation of motive power and motor speed, but has not so far been sufficiently tried in motor vehicle practice.

Different devices known as "atomizers" or "mixers" stand midway between the carbureter and the micrometer-pump systems, and are at present commonly used in American gasoline motor vehicles, and examples showing their mode of operating will be found in the following chapters.

The French carbureting system, however, is also extensively used in American motor vehicles, and is still being advocated by many competent engineers as the most reliable one for practical results at the present stage of the motor vehicle industry, and it is, therefore, necessary to understand the principle of these carbureters, while keeping in mind that their use has heretofore been connected with either a complicated transmission gear including many variable-gear contrivances and operating levers, or dependence upon driving belts of variable tension for speed changes.

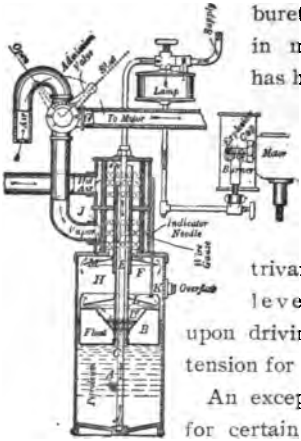


Fig. 5. Daimler Carbureter.

An exception must be noted for certain constructions, perfected very lately in France, in which speed control is effected by producing internal resistance to the exhaust stroke of the piston by blocking the passage for the exhaust gases. (See description of Vallée's system, p. 00.) This method can be used successfully only with a multi-cylinder motor, however, and requires to be supplemented by some system of control over the explosive charge in order to obtain sufficient range of power without going below the minimum of motor speed that is indispensable for satisfactory work.

It is also true that the power and speed of the explosion stroke may be modified within certain limits by varying the time of ignition and causing the explosion to take place before or after the highest compression of the charge has been reached; but even very skillful drivers find it difficult to make proper use of ignition adjustment while on march, and utilize their adjustment mostly to neutralize the effects of varying temperature on the action of the carbureter, i. e., as an offset to uncontrollable variations in the quality of the explosive mixture.

In the previous chapter a brief description of the De Dion-Bouton carbureter was given. In Fig. 5, the Daimler carbureter is illustrated.

A small gasoline tank, A, contains a float, B, which rests upon the gasoline. The float contains a central funnel connecting with the main body of the liquid in the tank. The liquid is thus maintained at a constant level in the funnel, but is isolated from the main body of the liquid. The funnel is arranged to slide upon a central guide, which is hollow and supplies heated air to the main supply of gasoline. The air is heated by means of a jacket carrying the exhaust gases on their way to the atmosphere; this jacket surrounds the air pipe. The heated air is then conveyed into the principal body of gasoline, thus becoming impregnated with the vapor, and this carbureted air is delivered through the valve G, where it is mixed with atmospheric air.

Fig. 6 illustrates one of the best-known French carbureters, the "Jupiter," in which the gasoline passes from the main storage tank, by a pipe, A, into an intermediary chamber provided with a float, C. As the level of the fluid in the intermediary chamber rises, it passes out by the passage E, and goes up the vertical tube F. The parts are so arranged that when the level of the fluid has reached a point close to the top of the pipe F, the float C rises, and the inlet pipe A is closed by means of the needle D. As the level of the fluid in the apparatus falls, the float C and the needle D also fall, thus allowing the fluid to pass along the pipe A. Air is drawn in through the opening G, and projected against the piece F. The latter is of special form, its exterior surface being conical and provided with three helicoidal grooves. The effect is to cause the indrawn air in rising to travel round the piece F, a preliminary mixture of the air and fluid taking place at the top of the said piece F. Arranged in an upper chamber are two small fans, H and H1, which, under the effect of the suction stroke of the motor, revolve automatically, further intermingling the air and vapor ere the carbureted air passes out through the opening I to the explosion chamber of the motor. The opening G can be regulated so as to allow any desired quantity of air to pass into the carbureter, while a regulating device is provided on the outlet pipe I, by means of which the quantity of carbureted air allowed to pass to the explosion chamber may be varied as desired. It is claimed that the carbureter, after once being regulated, gives a constant and steady supply of carbureted air, and that it can be employed for different sizes of motors, it only being necessary to enlarge or reduce the vapor outlet in the piece F.

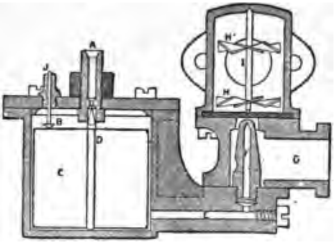


Fig. 6. Carbureter Jupiter.

Of special interest among the French devices for regulating the admission of gas mixture is that used in the Henriod vehicles, because it works as well with alcohol as with gasoline, and is designed to act independently of variations in temperature, this latter valuable feature, if it is really attained, being due to the same provision which is characteristic of the most modern American devices, namely, that of exposing no more of the liquid gasoline (or alcohol) to evaporation than is required for each explosion. To distinguish it from ordinary carbureters it has been called a "distributer," and it forms part of a vehicle construction that has been proved unusually reliable, at least for travel over French roads. During the week of the Paris-Bordeaux races in 1899, an eight horse-power Henriod carriage covered in all 2,400 kilometers, or 1,488 miles, without accidents of any kind, and 565 kilometers of this distance at a speed of seventeen miles per hour. The motor is notable for being the only two-cylinder gasoline motor as large as eight horse-power for which no cooling water is required.

The Henriod "distributer" (Fig. 7) is composed of a cylinder, C, with valves A and B, one above the other. The stem A of the lower valve passes through the whole apparatus, and A is actuated directly by the suction of the motor. The upper end of its stem is threaded to receive a nut, E, into which is also screwed a threaded bolt, V, whose lower extremity will abut against the upper end of the stem valve B when valve A is opened to a certain point. The distance between the bolt V and the stem valve B may be regulated by the screws so as to alter the inter-action between the valves at the pleasure of the driver. Valves A and B are held to their seats by springs R and r, respectively.

In the guide-piece surrounding valve B a cylindrical chamber, M, is formed which is in direct communication with the gasoline (or alcohol) tank by an orifice (shown in two dotted circles). When valve B is opened the liquid passes from this chamber m through the orifices O, O, and spreads itself over the upper surface of valve B. This conical surface has circular grooves which retain the liquid.

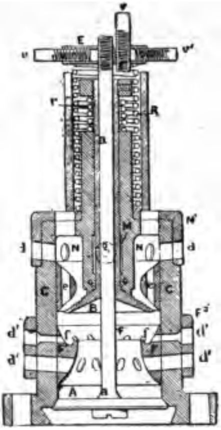


Fig. 7. Henriod Distributer.

The chamber N has, on its wall, orifices d, d, through which the outer air is drawn in by the depression of the valves, so as to bring it in contact with the two valve surfaces. This air absorbs the gasoline (or alcohol) vapors in passing the circular grooves in valve B, and passes then into the space F, which also has a circular groove, into which the surplus of gasoline from valve B falls. Through the orifices d1, d1, in the walls of chamber F, the outer air again mixes itself with the vapors and completes the carbureting process. The orifices d and d1 are automatically closed by rings, N1 and F2, whose rotation around the distributer may be regulated to diminish or increase the size of the air channels; but, once made, the regulation is permanent, as the admission of liquid is unvarying.

The air, before admitted to the distributer, is heated by passing through a box surrounding the exhaust pipe.

Compared with the best modern American vaporizing devices, the Henriod "distributer" is deficient in not including means for regulating the supply of liquid fuel, but, as the Henriod carriage is intended to be operated with unvarying motor speed, regulation is, from the constructor's standpoint, unnecessary. It may be doubted, however, if his method of allowing the gasoline to percolate into the "distributer" between two cylinders, one fitting closely into the other, is sufficiently accurate to secure an unvarying supply of the liquid.

CHAPTER III

THE QUESTION OF MOTOR SPEED

It may here be well to take note of some of the reasons why the unvarying motor speed is not a feature which is likely to be looked upon with favor in American vehicles. It necessitates, as before mentioned, frequent operation of variable-gear devices or the use of a driving-belt which may be manipulated to slip more or less on the pulleys over which it runs. In France, and most other countries where a high form of civilization antedates the construction of railroads, the highroads are, as a rule, hard and smooth, and the operating of gear changes is practically unnecessary except in the exigencies created by congested traffic, and in the case of steep grades on the road.

On the soft, rough and variable roads of the United States, on the other hand, the occasions for effecting speed changes are exceedingly numerous. Now it may be a depression in the road surface which would jolt the carriage severely if taken at the ordinary speed of travel; again, it may be mud, sand or frozen ruts, a short stretch of steep incline, a creek to be forded, an unfinished approach to a bridge, or any other of the accompaniments of an imperfect road system.

Under these circumstances the operation of the vehicle is likely to become an onerous task, as each manipulation of a change-gear device or tightening of a driving-belt requires muscular exertion; in this respect differing materially from the manipulation of a lever by which the power supply may be regulated as is the throttle of a steam engine or the switches of an electric vehicle.

But perhaps the most serious obstacle to the adoption of constant motor speed for hydro-carbon motor vehicles lies at another point. Constant motor speed means constant power development, and, if the vehicle shall have a considerable reserve of power to enable it to climb grades and otherwise discharge unusually heavy work, the power supplied by it when traveling at ordinary speed over ordinary roads must be largely in excess of the power that can be consumed in effecting propulsion. This surplus of power must be expended somewhere, and is, in the majority of gasoline motor vehicles, expended in jarring the whole vehicle in a manner disagreeable for its occupants and fatal to the durability of the whole mechanism.

Great efforts have been made to produce motors so "balanced" that the surplus power will expend its force in setting up internal and mutually opposite stresses in the motor proper, which stresses, by neutralizing each other, should be prevented from jarring the vehicle; and considerable progress has been made in this respect, but it still remains a fact that all gasoline motor vehicles operate most satisfactorily when the entire power supplied is consumed through high speed.

To prevent misunderstanding it may here be observed that the expression, "constant motor speed," is somewhat misleading. Even if the supply of gas mixture is unvarying for each explosion, and even if a governor device limits the number of explosions per second to a certain maximum, there are always variations, downward from this limit, due to load and resistance. Suppose a vehicle runs at a speed of twenty miles per hour on the level, and this speed is produced by a motor speed of 1,200 shaft revolutions per minute (or ten explosions per second), working with the highest gearing of the transmission mechanism, the moment a heavy piece of road is reached the speed of the vehicle may be reduced, and this speed reduction, arising from increased resistance, will react upon the piston speed, increasing the intervals between explosions. The power development, which depends in part upon the frequency of explosions, will be reduced correspondingly; and thus the anomaly arises with this type of construction that the more power is required to overcome resistance the less will be supplied. This will quickly lead to a dead stop of the vehicle unless the driver turns on a lower transmission gear and thereby restores the motor's ability to run up to its full speed. In fact, the skill of the driver consists largely in so operating the transmission gears that the motor is always checked by the governor, but not by the load. But this means, on the other hand, that the motor is always developing more power than can be utilized, and therefore results in more or less vibration of the vehicle. This is the result of the system which employs the carbureter and "constant motor speed"; and this system, while perhaps acceptable where good roads reduce the range of required power development to a minimum at the same time as they make a high average speed practicable, becomes singularly unfitted for the United States, where the opposite conditions prevail, namely, wide divergencies in the power required for the propulsion of any given vehicle under the varying conditions of travel, and frequent necessity for a slow pace.

The American line of progress runs, in full accordance with this reasoning, in the direction of controlling the speed of vehicles by increasing or reducing the power of each explosion through regulation of the fuel supply, while using gear-changes only for extreme cases. This involves a wide range of motor speeds, and compels the use of more than one, and preferably three or four, cylinders, in order to keep the motor shaft revolving when the motor is working at slow speed. Also in Europe the latest tendencies among motor vehicle engineers favor speed control by power regulation, but there are many difficulties yet to be overcome, and these for the present make the carbureter system the preferred one for practical vehicle purposes, especially where it is modified as described with reference to certain constructions mentioned elsewhere in this book.

In this country the desire to see the hydro-carbon motor vehicle developed to that point where the control of the motor power may be as nicely regulated as is the supply of steam power by means of the throttle, is sharpened by the lively competition which has here sprung up between gasoline motor vehicles and light vehicles operated by steam power, which leave nothing to be desired in regard to the adaptation of power to the work or smooth, noiseless travel; but in practice the progress which has been made in this respect has not yet been incorporated in any of the styles of gasoline motor vehicles which are being actually manufactured, while it is very notable in the production of motors which have not yet been adapted to vehicle purposes.

The nearest approach to a hydro-carbon motor which shall equal the steam engine in flexibility of power is, perhaps, that designed by Marius Marmonier, of France, and described on another page, and the Secor kerosene motor, made in this country.

The practical difficulties referred to arise chiefly from the explosive nature of the power stroke of the piston, which renders a high motor speed necessary if abruptness and jerkiness in the propulsion of the vehicle shall be avoided. The greater the number of cylinders (working on the same motor shaft), the less this necessity will be felt, and the greater will be the range within which the power of each explosion may be regulated to correspond with the resistance to propulsion, but it seems that there must always remain serious objections to lowering the motor speed below a certain minimum, which may, perhaps, be put at 500 shaft revolutions per minute for a duplex motor, but may be reduced somewhat when a larger number of cylinders is employed.

At a lower speed a loss of efficiency occurs from cooling of the expansive gases during the slow piston stroke, and from the inability of the flywheel to equalize the impulsions of the motor. Under such circumstances, it would be necessary to raise the power developed at each explosion by regulation of the quality or quantity of the explosive charge higher than would be necessary if the power were delivered uniformly to the transmission gear; and the result would again be fitful propulsion, vibration, tremor and deterioration of the mechanism.

The shortcomings of the hydro-carbon motor which have here been mentioned are responsible for several combination constructions by which it is the object to make the gasoline motor store up power in some form which may be utilized at the pleasure of the driver. Such are the motors in which the gasoline engine drives one or more air-compression pumps and stores the air in a tank from which it is drawn upon to drive the piston of an auxiliary cylinder; or motors which drive a dynamo that stores electricity which is utilized through an electric motor.

There are others who are endeavoring to devise hydro-carbon motors in which the explosive mixture would be delivered in a steady stream and fired and expanded by some process of continuous combustion in a tank, from which it should then be fed to an engine as steam from a boiler; but no notable progress has been made in this respect.

The best that may be hoped of the near future from hydro-carbon vehicles resolves itself, according to the foregoing, into a vehicle in which the speed reduction from motor shaft to the shaft of the driving wheels is sufficient to allow the motor shaft to revolve at, say, 500 revolutions per minute while the vehicle, with minimum load, travels at the slowest practicable gait over a level and hard road; and in which greater power may be developed by manipulating a lever controlling the fuel feed and producing greater motor and vehicle speed or stronger traction at the same speed, commensurate with the load and other conditions of travel. By the addition of a motor brake, acting to obstruct the exhaust, sufficient control over the lowest speeds (below three miles) may be gained (with a multi-cylinder motor) to make a construction of this kind as agreeable to travel with as any steam or electric vehicle. From present indications, it seems that a sufficient range of power may be obtained in this manner without making the capacity of the cylinders or combustion chambers variable (as in the Marmonier motor, p. 00), if only the fuel regulation is accurate and minutely graduated, and the system of ignition reliable even for much-attenuated gas mixtures.

It seems somewhat remarkable that nothing has yet been done to facilitate the use of cylinders of variable capacity, by devising some form of piston connection with the motor shaft, by which a variation in the piston stroke would be made possible. With the customary design, the simplest plan for obtaining power range without fuel regulation probably consists in an arrangement for cutting one or more cylinders out of action for low speed or light loads, and admitting them for high speed or heavy loads, and this expedient may, of course, also be employed in connection with a system of variable gas charges, and would contribute to remove the chances for disagreeable odor resulting from imperfect combustion of a weak charge.

CHAPTER IV

CONSTRUCTION FEATURES OF AMERICAN GASOLINE MOTOR VEHICLES—THE VALLÉE SYSTEM

To enter very deeply into a study of the transmission gearing, motor construction and controlling apparatus of each and every American gasoline motor vehicle would not repay for the labor, as the designs and expedients used are constantly undergoing changes and simplifications. A few examples will suffice to show the general character of the mechanical means employed for converting the hammering power stroke of the explosion engine piston into an equable and variable force for the propulsion of vehicles at any desired speed.

Among the early forms of construction that adopted by Mueller, of Decatur, Ill., may be mentioned briefly, because it is an adaptation of the system well known in Europe as the "Benz." It has not entered extensively upon the stage of manufacture in this country, however.

In these automobiles (Fig. 8) the frame of the running gear is made of steel tubes, a, which are utilized for carrying the cooling water, being connected by smaller tubes with the water-jacket b of the motor cylinder; a connection is also made with a system of tubes crossing and recrossing in

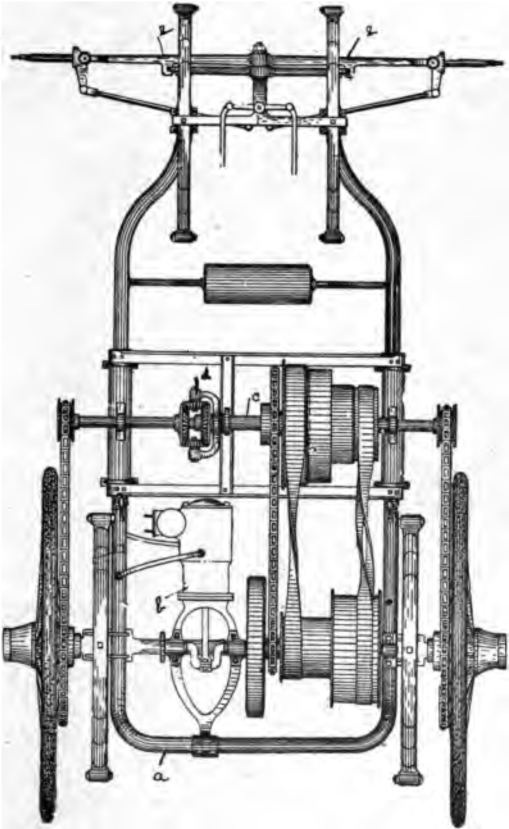


Fig. 8. Mueller System.

front of the vehicle, thus furnishing an increased cooling surface for the engine cylinder.

The power is transmitted, by a chain and belts on pulleys of various sizes, to the countershaft c which transmits the power by chains to the drive wheels. A differential gear, d, is used, as is always the case in single-motor vehicles, as, when turning, it allows the outside wheel to revolve faster than the inside wheel.

The gasoline vehicles made by the Lewis Motor Vehicle Company, which are largely of the style intended for merchandise-delivery service, are equipped with a single-cylinder four-cycle motor, designed to be run at "constant speed," and depend upon the manipulation of the transmission gears for changes of speed and load.

The transmission gearing (Fig. 9) is, therefore, the most notable feature in their construction. The power is transmitted by friction pulleys from the motor to the countershaft, by gear wheels from the countershaft to a second countershaft, and by chain and sprocket from the latter to the differential gear on the rear axle. The small pinions on the countershaft are faced with rawhide. The illustration shows the position of the friction pulleys which gives the highest speed.

The second speed is secured by moving the countershaft laterally; by this means, the large pulley on the countershaft is brought in contact with the smaller pulley on the crank-shaft, and the small pinion into engagement with the large gear on the driving-shaft. Very slow speed is obtained by causing slippage between the friction pulleys, one end of the countershaft being held in an oscillating bearing, which has a connecting rod carried forward to a rock-shaft actuated by the operator's foot; the latter brings the friction disks into engagement, and is the means of giving any variation of speed from zero to the second speed. To reverse the power, the rock-shaft is tipped for-

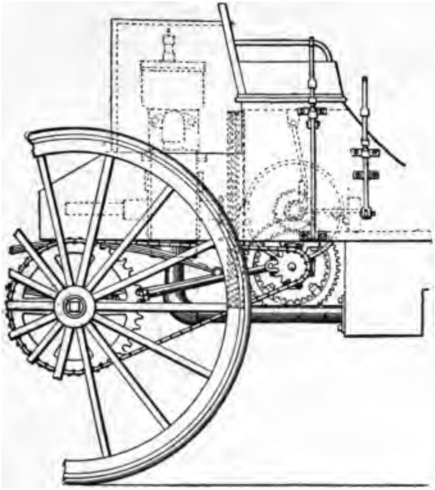


Fig. 9. Rear Portion of Lewis Motor-Vehicle Mechanism.

ward, and the lever under the driver's seat on the right side is brought to a vertical position, thereby throwing a small friction pulley into engagement with the slow-speed friction pulleys on the countershaft.

A water tank is located immediately under the footboard of the vehicle. A pipe leads from the water jacket of the cylinder to the top of this tank; then from the bottom of the tank to the top of the cylinder jacket. Connected with the pipe, at a point near the cylinder, is a small rotary pump that produces a constant circulation of water through the water jacket, tank and pipes. This pump is operated by a pulley and belt connecting with a pulley on the crank-shaft. On the front of the vehicle, entirely covering the dashboard, is a condenser consisting of a number of horizontal pipes with the ends connected to headers, themselves connected by pipes with the water tank just mentioned. On the opposite side of the vehicle and parallel to the motor is an elongated cylinder, or expansion chamber, connected by pipes to the combustion chamber of the cylinder, and acting as a muffler.

Among other American motor vehicles in which the ingenuity of the transmission and operating gear arrangement is relied upon for adjusting the power of a single-cylinder motor to variations in load and speed, the Winton carriages have at-

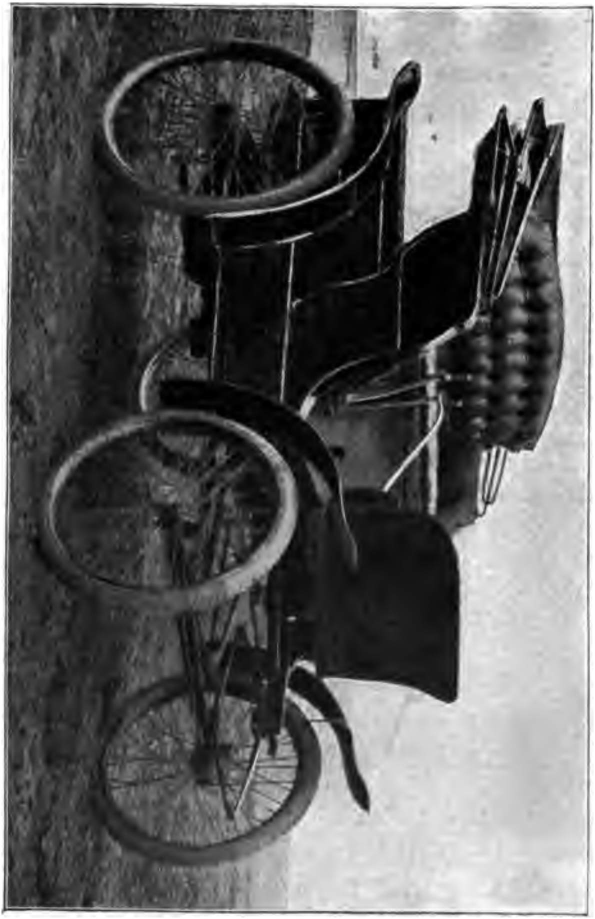


Fig. 10. Winton Phaeton.

tracted much popular attention, being among the earliest motor vehicles that were manufactured and sold in considerable number. A carriage of the style shown in Fig. 10 completed a successful journey from Cleveland to New York at an average speed of about fifteen miles per hour, and without any other serious accident than the breaking of the front axle. Within certain limits, the operator of a Winton carriage may control its speed by throttling the admission of gas mixture, but otherwise the construction follows those lines which are being abandoned by most designers in favor of more flexible multi-cylinder motors, less weight and less machinery. Good working results are attained in the Winton vehicles by intelligent selection of the mechanical elements and rigorous exclusion of expedients that have not proved durable. The feature most highly valued by their users is the arrangement by which one operating lever may be used for starting and for backing, while the other operating lever is sufficient for all ordinary operations on the road except steering. When this lever is in a vertical position, both the brake and the fast go-ahead clutch are out of operation. The movement of the lever in a forward direction applies the clutch, and the brake band is still further slackened. The movement of the lever in a backward direction beyond a vertical line applies the brake and releases the clutch;

it is impossible to apply the brake when the clutch is applied, but a single movement of the lever puts the engine out of gear with the driving-shaft and applies the brake. The other lever operates the backing clutch and the slow go-ahead clutch by a similar movement.

Duryea motor vehicles, based on Duryea patents, are manufactured in several factories, and are recognized as being the earliest type of gasoline motor vehicles especially designed for American conditions. They have been very successful in speed contests since 1895, not only in this country but also in Europe. All Duryea vehicles are rear-driving, with the weight placed well over the driving wheels; and front steering, with the steering wheels placed well forward, making a long wheel base in order to minimize the likelihood of side slip.

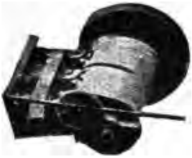


Fig. 11. Compact Three-Cylinder Motor.

Fig. 11 shows a Duryea three-cylinder motor. A two-foot rule lying across one end of this shows its size, as used in most of the vehicles manufactured for pleasure purposes. It is 18 inches square by 10 inches deep, with a fly-wheel 16 inches by 3 inches outside this space on the crankshaft. The cylinders are 4½ bore by 4½ stroke.

A single feed-pipe supplies all three cylinders at the head of the motor, and a single exhaust chamber, lying on top of cylinders, carries the gases to the muffler; similarly the wiring for electric ignition and the cam gear for operating valves is little more complicated than for a one-cylinder motor.

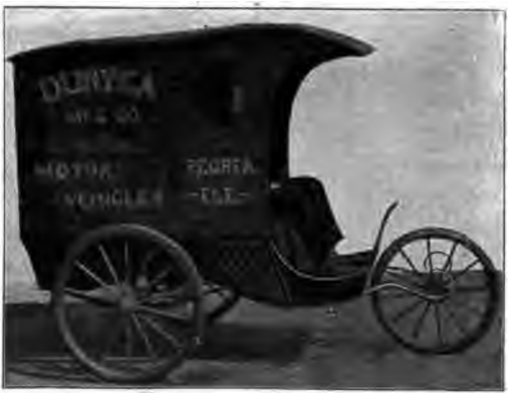


Fig. 12. Three-Wheeled Delivery Wagon.

The most efficient piston speed is about 500 revolutions, but this may be varied to as low as 75 turns per minute on good roads, and as high as 1,000. The regulation is accomplished partly automatically by the load and road resistance, and partly by the fuel admission, which is under command through the single operating lever. The "mixer" operates as a siphon, the induction stroke drawing in air through a pipe in the center of which is a smaller tube leading to the gasoline supply. The passage of the air draws the liquid gasoline into the air pipe in a finely-divided spray and vaporizes it. The quality of the mixture is varied by throttling the air current.

All the working parts are on top in plain sight, where they can be easily gotten at or taken care of when they need attention. The cover over the crank-shaft can be quickly removed, and the crank-shaft, the connecting rods and the pistons easily reached. Oil cups screw into each cylinder, and oil from the cylinders finds its way to the crank-shaft case and keeps all bearings therein oiled by splashing. Peep caps are provided for the purpose of examining the valves or sparkers, or watching the sparks in operation. Unless very high speed is required, no timing device for varying the point of ignition is used, but the gas mixture is ignited at its highest compression.

The transmission device consists of a direct connection by sprockets and chain from motor shaft to rear axle at all ordinary speeds on level ground. In addition, three friction clutches connect the motor and the vehicle, and vary the speeds for slow or backward driving. These clutches may also be used as a brake. A brake is also applied to the inside of the large sprocket on the driving shaft or rear axle.

Fig. 12 illustrates a three-wheeled Duryea delivery wagon.

The French De Dion-Bouton construction for light motocycles has been adopted in this country by the Waltham Manufacturing Company, and these vehicles are illustrated in Figs. 13 to 16. Fig. 17 shows the motor, the operation of which was explained and illustrated in a previous chapter (Fig. 4, p. 45). It may here only be added that the fly-wheel in these motors takes the form of two balanced disks (u in Fig. 17), which revolve in a crank chamber partly filled with oil, so that lubrication of crank-shaft and piston takes place automatically when the motor is working. Tandems and tricycles of the type illustrated have been frequently used for pacemaking at bicycle races during 1899. When thus used, the mufflers are generally removed from the vehicles in order to get the highest possible speed development, and under those circumstances the noise from the exhaust is therefore much more noticeable than when the motocycles are used for pleasure riding.

Motocycles of very similar design and motor power are made by the Canda Manufacturing Company, and are called Auto-Quadricycles.

In Olds gasoline motor vehicles, the motor is mounted on the truck, leaving the carriage box free from incumbrance by machinery, and the motor mechanism together with the clutches, for

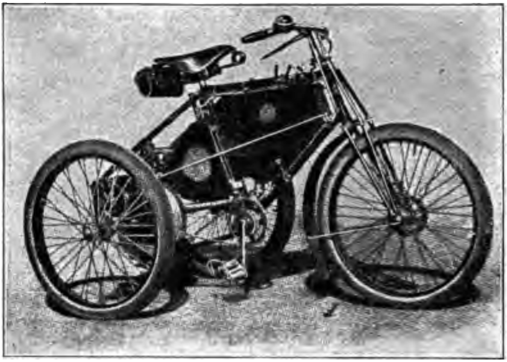


Fig. 13. Motor Tricycle.

gear speed changes, is enclosed in a single casing. The ignition is regulated by the operating lever so as to produce late firing when the vehicle

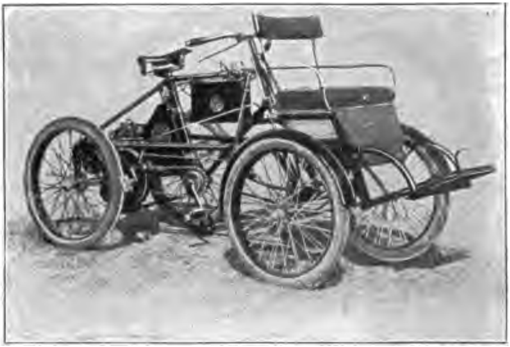


Fig 14. Motor Quadricycle.

is started and early firing when greater speed has been reached. The starting operation also relieves compression of the explosive mixture until the motor is going. By late firing, when the motor is at a standstill, the impulsion from the first explosion acts upon the piston when the crank of the motor shaft is past the dead point, and when the mechanism, therefore, is in the best position to be started going.

In the illustration given of a Hertel carriage (Fig. 18), made by the Oakman Motor Vehicle Company, it is noticed that each front wheel is mounted so as to have an independent vertical movement assisting the carriage in conforming to a rough road surface. The entire motor mechanism and driving gear is accessible for caretaking and light repairs, at a convenient height, by raising the sheet metal tailboard of the wagon.

The power transmission is by means of V-friction pulleys on each end of the countershaft, which internally engage leather-covered rings secured to the rims of the driving wheels. The V shape of the rings and grooves taken in connection with the leather covering of the large diameter rings makes the friction drive efficient with a very light pressure. The countershaft carries a twenty-four pound fly-wheel, and is driven by two pinions meshing with two spiral gears on the crank-shaft. These gears are quite noiseless in action. Above

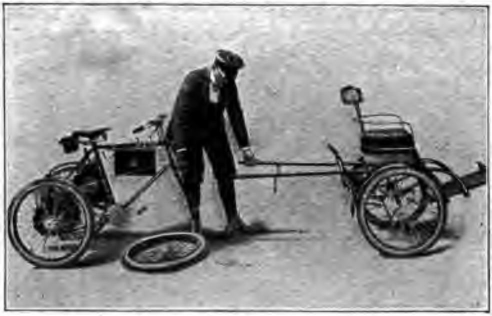


Fig. 15. Coupling of Motor Quadricycle.

the motor and under the seat are two tanks separated by a small space. The left is for storage of gasoline, and carries about two gallons. Inside this tank is a carbureter, and on top of the tank a safety valve, which prevents excessive pressure.

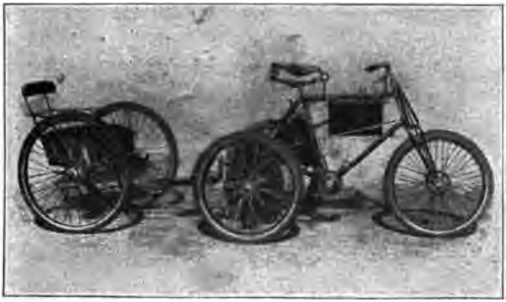


Fig. 16. Motor Tricycle with Trailer.

The right tank is for water, and has a capacity of six gallons.

By throwing in the low gear, keeping the motor running and the friction pulleys in contact with the driving rings, the speed of the wagon is controlled by the motor, and the speed of the motor is, to a certain extent, determined by the operator, namely, in so far as the gas mixture may be varied by throttling the air inlet. The supply of mixture is controlled by the grip on top of the lever which rises in front of the seat, and is limited by a governor.

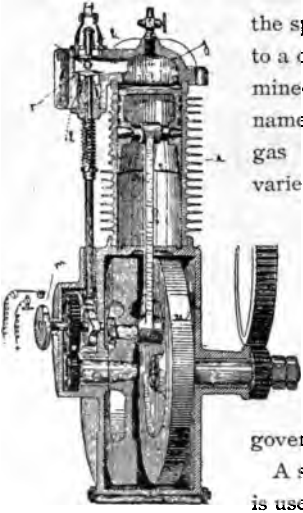


Fig. 17. Dion-Bouton Motocycle Motor.

A small storage battery is used to supply electric current for sparking, in starting the motor. When the motor is started the battery is cut out by a switch on the seat, and current is taken from an electric generator driven from the fly-wheel by means of a friction pulley. Unlike most other gasoline motor vehicles, the wagon is started from the seat by moving a lever to and fro. This hand lever, operated with the left hand, starts and stops the motor, changes the speed, engages and disengages the driving mechanism, releases and sets the brakes; in fact, controls every operation except gear changing and steering.

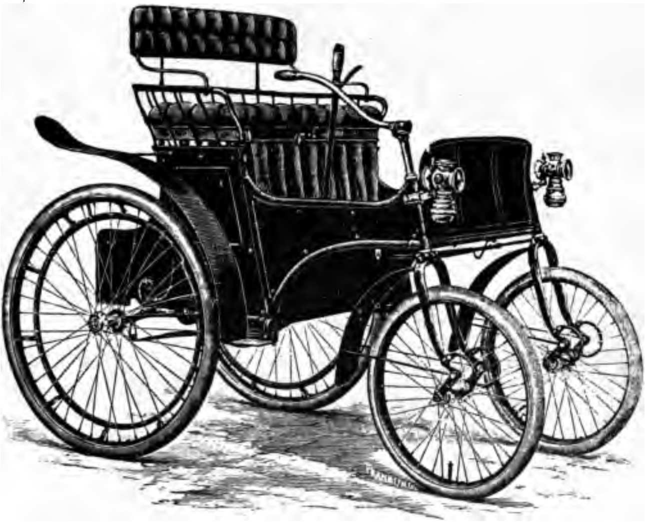


Fig. 18. The Oakman Motor-Vehicle. (Hertel System.)

The Loomis Automobile Company makes three styles of vehicles, among which a 2½ horse-power park wagon that weighs only 315 pounds. All the machinery is hung in a casing under the rear axle. The cooling of the motor is accomplished entirely by radiation, so as to obviate all danger from freezing of water if the carriage is left standing in winter time.

The Detroit Automobile Company makes seven styles, weighing from 1,200 to 2,000 pounds. They are all started from the seat by the same lever by which the friction clutches and the reverse gear are operated. The motor has two cylinders of the ottocycle type, normally turning the motor shaft at the rate of 600 revolutions per minute, at which speed the vehicles travel five miles per hour when the friction clutches are firmly set to lowest gear speed.

A radical departure in construction has been inaugurated in a carriage made in New Haven, Conn. The motor is composed of four cylinders operating on a cycle of eight strokes instead of the usual four, so as to give one explosion for each turn of the shaft, namely, one in each cylinder every fourth turn. The time elapsing between explosions makes water cooling unnecessary, and no cooling devices are employed except a few radiating ribs over the explosion chamber. The gas mixture is regulated by the usual siphon device, but in order to have each cylinder miss every other induction stroke, a governor, operated by compressed air, holds the exhaust valves open and the admission valves closed, when required, so that nothing but air is taken in and expelled;

and the air serves to cool the cylinders on the inside. The compression of the charge, with this arrangement, amounts to a resistance of 45 pounds in cylinders 3¾-inch diameter and 5¾-inch stroke, four of which produce six horse-power. The volume of air passing through the "mixer" (and thereby the composition of the gas and the speed of the motor under given conditions) is regulated by a graduated disk valve controlled by an attachment to the main operating lever.

The power transmission is by means of a rawhide bevel pinion on the motor shaft engaging with two clutch gears, one for forward and the other for reverse motion. The clutch gears work on a hollow countershaft which contains a rod which actuates two clutch collars, making one or the other of the two bevel clutch gears tight on the countershaft. On one end of the countershaft is the normal speed gear, and on the other end the slow gear, and these engage two driving gears on the rear axle, driving at normal or slow-gear speed according to which driving gear is clutched to the axle. A hand brake surrounds the compensating gear, which is of the customary design.

As an example of simplicity in construction and modern use of a motor brake for governing the power of the motor a description of the French Vallée vehicle now follows, which is of special interest because it shows one of the latest French types, and one which, perhaps, comes as near to answering American requirements as any so far produced in this country.

The illustrations (Figs. 19 and 20) show only the frame and running-gear, which may be used with varying designs of carriage body.

The motor is placed in the front portion of the vehicle and comprises four cylinders operating on the Otto cycle, giving two impulsions to the motor shaft for each revolution. The motor speed is limited by a governor, and the ignition is by electric spark. The power is transmitted to the rear wheels by the belt G which connects pulley H^1 on the motor shaft with the drum H on the rear axle. There are thus no change gears at all in the construction. All speed changes are effected either through the motor organism or by allowing slippage of the driving belt.

When the highest speed is permissible the governor limits the motor to its normal high speed. When a slower pace is wanted the driver depresses the pedal B (Fig. 20), which partially or entirely closes the exhaust, thereby producing an internal resistance to the exhaust stroke of the piston which retards the motor speed. The driver may also advance or retard the ignition by the usual device for this purpose, and thereby influence the motor speed within certain limits.

Referring to the illustrations, the box A contains

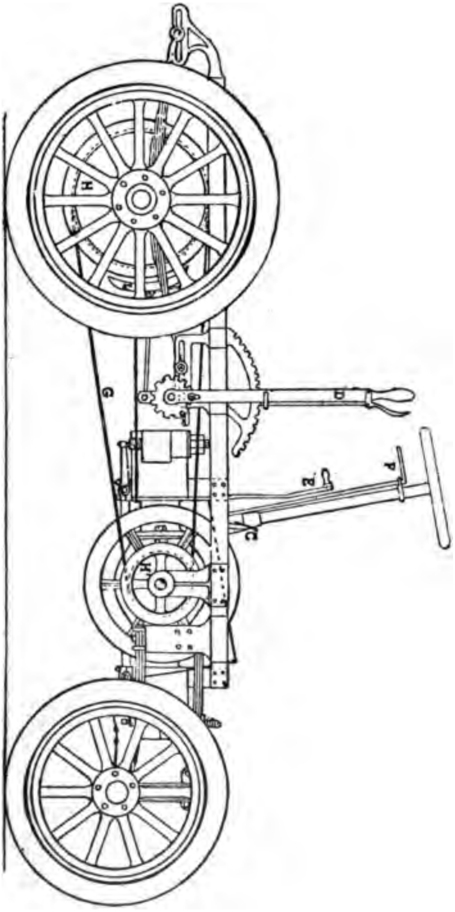


Fig. 19. Side-View Elevation of the Vallée Vehicle.

the cams that control the exhaust, the ignition apparatus and the governor. The carbureter I is placed in front. On the pipe which connects it with the cylinders is the stopcock by which the explosive mixture is regulated through operation of the rod F, and on the exhaust pipe running alongside of it is the stopcock by the turning of which the speed of the motor is regulated; it is actuated either by the governor (at the highest speeds), or by the pedal B as before mentioned.

The frame of the vehicle is entirely of steel tubes.

The drum H contains within it the differential gear K and the reverse gear J, controlled by the lever E. The transmission belt is very broad, and may be tightened or slackened by the lever D, which acts by pushing the rear axle backward, the carriage springs by which the axle is connected to the frame being arranged to slide, in the manner plainly shown in Fig. 19.

Two mechanical brakes are provided to comply with French legislation on this point; one acts by expansion inside of drum H, and is actuated by the pedal C, and the other, a shoe brake, is actuated automatically when the driving belt is slackened by lever D, and acts externally on drum H.

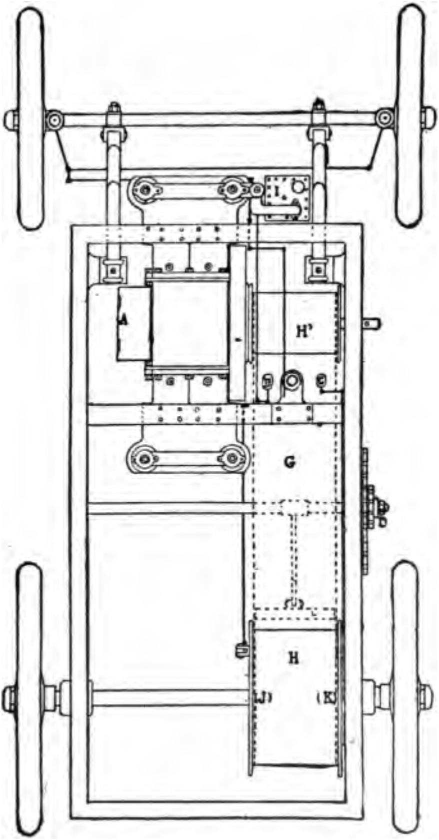


Fig. 20. Plan of the New Vallée Vehicle.

CHAPTER V

IGNITION, COOLING AND EXHAUST

There are two methods in common use for igniting the explosive mixture in hydro-carbon motors, i. e., hot tube and electricity. As the hot tube is not used in automobiles in this country, we will not enter into its description in detail.

The problem of producing unfailing ignition of the explosive charge in hydro-carbon motors is one of the most important which faces the designer and engineer, because the best motor becomes tricky and useless unless absolute dependence can be placed in this function.

The electric spark is theoretically the ideal means of ignition, but much trouble has been experienced by designers, either from ignorance of the laws of electricity or on account of the extraordinary conditions which attend the making of the spark in the hydro-carbon motor cylinder. There is in reality nothing very difficult or troublesome in this application of electricity, if only the conditions that surround it, from both a mechanical and electrical standpoint, are thoroughly understood. Most designers in their early electrical experiments have tried to use the Rhumkorff or induction coil. The theoretical advantage of this apparatus is that the spark does not require actual contact of the electrodes, but, from the intensely high pressure of the induced or sparking current, will leap across a considerable air space, and thus the necessity for mechanical contrivances and perishable electrodes is done away with.

However, the difficulties attending the practical use of this current are almost, if not quite, insurmountable in hydro-carbon motor practice, as the intense current, by its very nature, resists all ordinary means of insulation. The engineer is, therefore, forced to resort to other methods.

The best spark-apparatus consists of from five to ten cells of good battery, sending a current through a carefully made spark coil.

The spark coil is, strictly speaking, an induction coil, but, in trade, an induction coil is understood to refer to a coil made with one or two layers of coarse wire, through which an interrupted battery current of moderate power is sent; this coarse wire winding is covered with another winding of many thousand feet of very fine, carefully wound wire, between the terminals of which the induced spark passes. The true spark coil, on the contrary, consists simply of a core of soft iron wires, upon which from six to fifteen layers of well-insulated, comparatively coarse copper wire are wound. This is connected with a primary battery of such power that, if the terminal wires are brought into momentary contact with each other, at the moment of separation a spark jumps between the separating electrodes. Both the length and intensity of this spark are important in the ignition of a hydro-carbon mixture, and are determined by the number and character of battery cells in use, and also, in a large measure, by the character and care used in the manufacture of the spark coil. It must be made of the purest materials, thoroughly insulated and carefully protected from the effects of moisture and mechanical damage.

To produce the spark in the cylinder, it is necessary to provide two pieces of metal (electrodes) electrically insulated from each other. The action of the engine must bring these into contact at such a time that their separation will occur just when the explosion is desired. This contact and separation can, of course, be timed to take place at any point in the stroke, and it is this feature which makes electric ignition so ideally perfect and productive of such excellent and most economical results.

In the practice of hydro-carbon motor manufacturers, the methods of making the contact are as various as the motors themselves; but the designer of this part of the motor must keep in mind two important conditions attending a perfect spark. The contact between the electrodes must be absolute, and the break or separation should be as sudden and as wide as possible. For this reason, some form of a wipe-contact is generally employed, the electrodes being arranged to slip by one another. This insures a continual cleaning of the surfaces, hence a good contact, and, if there is sufficient spring, a wide separation; the spark follows and attempts to bridge the break; hence a wide break makes a long spark.

Mere length is not the only requisite of the spark; it should be "fat," and have considerable heating effect. This will be known by its color, which should be a rich yellow, with considerable illuminating power, as contrasted with the least desirable spark, which is thin and pale-blue in color, and has but little power to ignite an attenuated mixture. The character of the spark depends largely upon the battery used, and almost as much on the spark coil. The storage battery, or accumulator, gives the best current for this purpose, as it is very constant and maintains its pressure very evenly until it is exhausted. Where there is an electric current available for charging accumulators, they will be found very satisfactory, if of a good type.

In some hydro-carbon motors where the spark apparatus has been carefully designed from an electrical standpoint, the use of a high-class sal-ammoniac battery is admissible, and, in some such cases, these batteries have a record of from six to eighteen months' continuous service without any attention. In the use of the sal-ammoniac battery, the insulation in and about the motor is of more immediate importance than when the constant current battery is employed; and, at this point, manufacturers have often been led into trouble by the fact that some of the best insulators are entirely unfit for practical use. Means which can be employed in ordinary electrical practice are entirely inadmissible in the cylinder of a hydrocarbon motor. The intense heat and the enormous pressure are the two most trying conditions. Some kind of porcelain would be a satisfactory insulator, but there is some danger of breakage from shock, although by careful design and construction this can be avoided to a large extent. Next in value is good mica, but in practice asbestos is the insulator most generally used. There can be no objection to a proper thickness of asbestos if the material is good, but a large amount of trouble has resulted from the poor character of some of the asbestos on the market. Mineral wool is used largely to adulterate this material, and as mineral wool is mostly a product of the blast furnace and contains considerable iron and other conducting substances in its composition, it is obvious that much trouble is to be looked for where this adulteration has been practiced. Every sample of insulating material should be thoroughly tested electrically. This can be done by simple and well-known means, thus saving a vast amount of trouble. After the motor is set, the various insulated joints should be carefully tested, not merely with the current from the sparking battery, but by a magneto-bell, or, better still, by a careful measurement of the electrical resistance.

The spark mechanism in its simplest form is simply an electrode on the piston head, which comes in contact with a fixed, insulated electrode in the head of the cylinder. Where no rubbing contact is attempted, the contact surfaces should be thoroughly protected with platinum, a metal which is not readily burned by the electric spark, and thus always presents a clean surface for contact. But this form of contact makes a very short spark, as it takes place at the very time when the piston is at rest. To increase the length of the spark, the fixed electrode, i. e., the one on the cylinder head, is sometimes made of spring metal, so as to snap past the movable electrode.

Many plans have been resorted to to obtain this action in the best manner, for, of course, the great heat in the cylinder draws the temper from any kind of spring, although in some engines comparatively large iron bars have proved very satisfactory; the spring, while not being very violent, being sufficient to insure a rubbing contact and considerable separation of the electrodes. In the best designs, however, the electrical mechanism is separated from the piston and is actuated by cam, gear or eccentric on the motor shaft outside of the cylinder. It can thus be timed right, and any amount of motion can be given the electrodes, even at the instant when piston-head electrodes would be in unmoving contact.

The latest form of ignition apparatus does away with primary batteries, and substitutes storage cells of a known quantity. These are kept charged by a small generator connected by belt or friction device with the motor, giving a constant source of supply to the accumulators.

Closely associated with the question of ignition is that of tempering the heat absorbed by the walls of the combustion chamber, and especially the parts adjacent to the admission valve, after each explosion, so that the next explosive charge will not be fired before the electric spark is made.

The time limits within which the required reduction in temperature must be effected are very narrow, and are determined by the rotary speed of the motor shaft, two revolutions of the shaft corresponding to one explosion (in each cylinder) in an Ottocycle motor. As a motor speed of 1,200 revolutions per minute is very common for small motors, and 2,500 not unheard of, the fraction of a second in which the cooling must take place is so very small that its duration can barely be conceived mentally. Those not familiar with the action of gas engines may, however, form an approximate idea by tapping very rapidly with the point of a lead pencil on a piece of paper, while holding a watch to time the operation for five seconds; if the dots made on the paper count up to 50 in five seconds, the tapping corresponds in rapidity to the succession of explosions in a one-cylinder motor going at 1,200 revolutions, or 600 explosions, per minute. The time between the taps is nearly four times as long as the time allowed for cooling the cylinder.

In a motor with two or more cylinders, the chance to cool is increased by two factors: (1) other things equal, each cylinder may be smaller than in a one-cylinder motor, and (2) it may be worked with smaller shaft speed.

That a small cylinder cools more rapidly than a large one depends upon the mathematical fact that the surface which radiates heat is larger in proportion to the capacity of the cylinder than in the larger cylinder, areas being determined by the square of linear dimensions, but volume (capacity) by the cube.

The means employed for cooling vary in accordance with this simple principle. In very small motors radiation is sufficient if the cylinder is so placed that it is freely exposed to the action of the surrounding atmosphere, but in order to increase the radiation the cylinders are provided with ribs or flanges as shown in Figs. 4 and 17. The same is the case with larger motors of the multi-cylinder type, if each of the cylinders is small; but there is usually a loss of radiation from the necessity of placing the cylinders close to each other, so that the air cannot play freely upon them all.

In most multi-cylinder motors it is, therefore, preferred to surround the cylinders with a jacket filled with water and connecting with a water tank, and the water is kept in circulation by a pump operated by a connection with the motor shaft.

If the water absorbs so much heat that it is brought to the boiling point, the steam generated is generally disposed of through the exhaust pipe of the motor, and the water must then be periodically renewed.

In most modern vehicles the water jackets and the water tank are studiously exposed to radiation in order to prevent the water from reaching the boiling point, and thus avoid the inconvenience of renewal and the troubles that would ensue if the supply were depleted unawares.

Other precautions are taken to make air radiation sufficient, or at least reduce the quantity of water to be carried.

In the famous "Duke" style of pleasure and racing carriage, of which an example is shown in Fig. 21, and which is very common in France, the cylinders are placed vertically in the very front of the vehicle, and are provided with large radiation flanges fully exposed to the action of the atmosphere by lattice openings in the front and rear (or top) of the box containing them.

In certain makes provision is made for introducing cool air to the inside of the cylinders between explosions, and one of the latest racing vehicles of the Daimler type keeps a fan revolving to assist in cooling when the vehicle is going at a slow gait, or is standing still with the motor running.

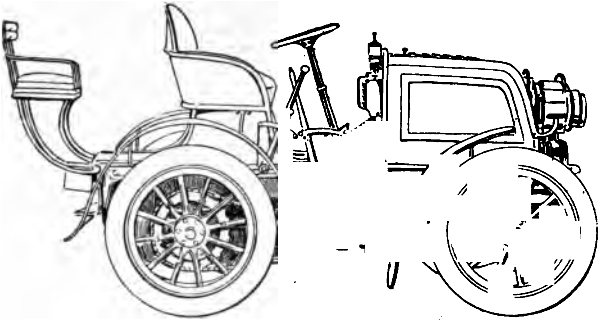


Fig. 21. Racing Vehicle of the "Duke" Pattern.

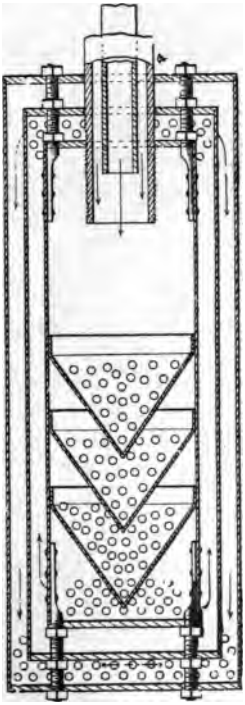
The greatest difficulties in regard to cooling have been experienced with two-cycle motors on account of the rapid succession of explosions at a given speed, but most of the small marine motors now used in the United States are nevertheless of this type, of which an illustration is given in Fig. oo p. oo, and it is claimed that all danger of premature ignition has been removed, and that these motors are perfectly reliable. But they have not as yet been tested extensively for automobiles.

The burnt gases contained in a cylinder after the power stroke is finished retain a large part of the expansive energy produced by the combustion, and seek an outlet with considerable force. If the exhaust valve opening and the exhaust pipe by which they are permitted to escape are too small, an objectionable commotion and noise will accompany this function; and, in fact, more or less puffing is always caused at the exit where they commingle with the atmosphere, unless an efficient muffler is interposed to diffuse and equalize the puff.

Sometimes the pressure of the gases is partially relieved by a port in the side of the cylinder, said port being over-traveled by the piston so as to be open only at the moment when the piston is at the end of the power stroke and the beginning of the expulsion stroke.

The exhaust valve is usually located in the head of the cylinder, and is opened and closed by a positive gear-connection with the motor shaft.

In most modern motors a considerable portion of the burnt gases is retained in the cylinder and utilized for diluting the explosive mixture, and in some cases provisions are made for varying the volume retained in order to modify the force of explosions. In other systems it is preferred to expel them completely and draw in atmospheric air, instead, to dilute the gas mixture, thereby effecting more rapid cooling of the cylinder.



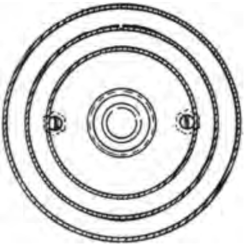


Fig. 22. Muffler, Hydro-Carbon Type.

The speed of the motor may be automatically limited by a centrifugal governor which, when the motor reaches its highest permissible speed, closes or partially closes the exhaust valve orifice, and thereby retards the expulsion stroke. More important is the method of throttling the exhaust by means of a hand-operated lever, and thereby controlling the speed of the vehicle in all its stages without severe muscular effort. Reference is made to this form of motor-brake elsewhere in this book, but it is still doubtful in this country to what extent the method may be utilized without risking premature ignition of the next charge.

As an example of muffler design there is presented in Fig. 22 an illustration of the muffler used in Duryea vehicles. It consists of three cylinders, one within the other, each having its ends closed except to admit a pipe, a, for the exhaust gases. The first or interior cylinder has three cones provided with perforations which diffuse gases coming from the combustion cylinder and the steam from the water jacket surrounding this cylinder.

When the gases enter the first cylinder under high pressure, they encounter the cones, and are passed into the second cylinder under lower pressure. Leaving this cylinder at the opposite end, they retrace their course, under still lower pressure, into the third and last cylinder, passing out at nearly atmospheric pressure and almost noiselessly.

CHAPTER VI

MODERN GASOLINE MOTORS—GOVERNORS

The motors mentioned in this chapter, while not known to have been applied to any of the motor vehicles which are obtainable in the market, are among those most advanced designs for other than vehicle purposes from which good results may be expected also for automobile work.

In two or three modern four-cycle motors, barely out of the experimental stage, the liquid gasoline is pumped into the air tube through which the motor draws its fill by the suction stroke and is vaporized by the passage of the air, no more hydro-carbon vapor being mixed with the air than the deposit of liquid gasoline permits. By regulating this deposit the composition of the mixture may thus be regulated without throttling the air supply. The diminutive gasoline feed pump is in these motors worked from the motor shaft, and the quantity of gasoline which it deposits for each explosion depends entirely upon the adjustment of the pump stroke and not upon the velocity of the air current created by the induction stroke of the piston, which varies with the motor speed. So far as known the designers of these modern motors have not gone to the length of also varying the quantity of air admitted by providing arrangements for shutting the admission valve before the suction stroke of the piston is completed, but construction of this nature may perhaps be looked for in a near future, and would apparently contribute to giving the motors a wider range of power.

One of the latest motors to be adapted for automobile work is the Yale two-cycle engine. As in other two-cycle motors, the gas mixture is first drawn into the air-tight crank-chamber, and is from there transferred to the space above the piston after being compressed by the power stroke and after the burnt gases occupying the explosion chamber have been released through an exhaust port in the cylinder wall. In the Yale motor, the transfer takes place through an external connecting pipe that opens into the middle portion of the cylinder wall, just above the piston when the latter is at the end of the power stroke, and into the top of the crank chamber. In the illustration Fig. 23 are shown the main parts of the motor. The crank shaft is shown to the right; against it rests the rotary valve plate M, which in use slips over the end of the crank shaft and fits loosely on a boss made to receive it. The plate M is driven positively by the small pin R, shown on the left-hand crank throw, and is spring-seated on the crank case cover C, shown at left of fly-wheel. As the crank revolves (in a spray of oil) this plate

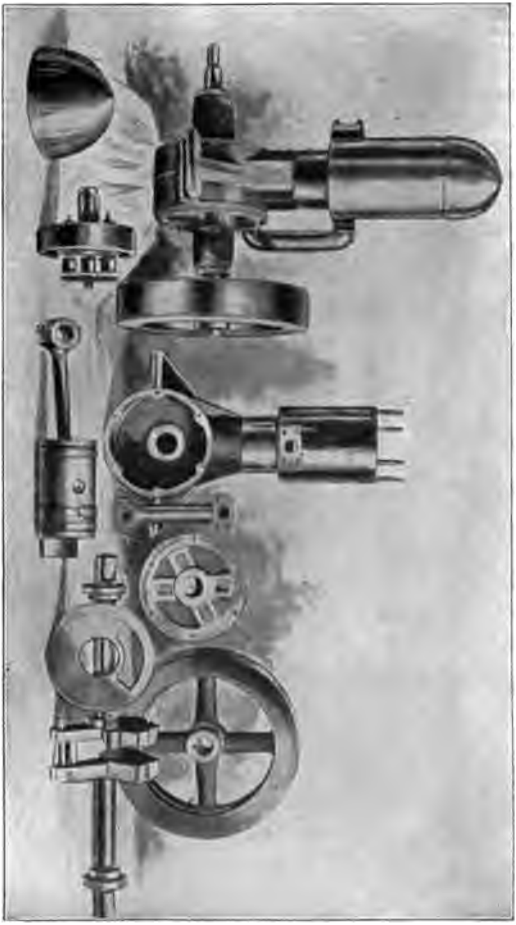
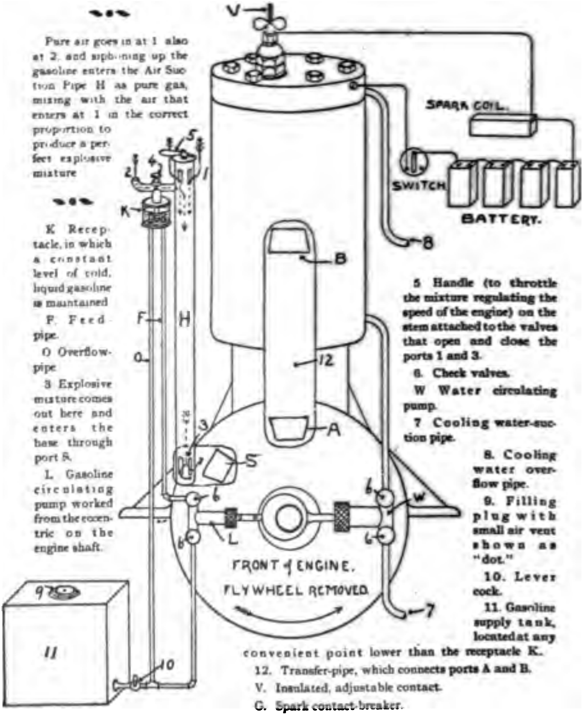


Fig. 23. Parts of Modern Two-Cycle Motor.

opens and closes the suction port S and transfer port A with certainty.

The system of vaporization consists essentially of a supply tank, 11, Fig. 24, which is somewhat lower than the receptacle K, and a gasoline circulating pump L, which, while the engine is run-



Pure air goes in at 1 also at 2, and siphoning up the gasoline enters the Air Suction Pipe H as pure gas, mixing with the air that enters at 1 in the correct proportion to produce a perfect explosive mixture.

K Receptacle, in which a constant level of cold, liquid gasoline is maintained.

F. Feed-pipe.

O Overflow-pipe.

3 Explosive mixture comes out here and enters the base through port S.

L. Gasoline circulating pump worked from the eccentric on the engine shaft.

5 Handle (to throttle the mixture regulating the speed of the engine) on the stem attached to the valves that open and close the ports 1 and 3.

6. Check valves.

W Water circulating pump.

7 Cooling water-suction pipe.

8. Cooling water overflow pipe.

9. Filling plug with small air vent shown as "dot."

10. Lever cock.

11. Gasoline supply tank, located at any convenient point lower than the receptacle K.

12. Transfer-pipe, which connects ports A and B.

V. Insulated, adjustable contact.

G. Spark contact-breaker.

Fig. 24. Diagram of Yale Motor.

ning, pumps a small amount of gasoline into the receptacle K, which is attached to the air suction pipe H. In order to make this reliable, the pump L pumps faster than the gasoline is used, the surplus flowing back into the tank. This results in an even height of gasoline in receptacle K.

As the air is sucked into the suction pipe H, through openings 1 and 2, it siphons up the required amount of gasoline, which is adjusted by a micrometer screw, 4, and one adjustment only is necessary for a given engine.

The speed of the engine is controlled by two throttling valves on one stem, operated by the hand-lever 5 (or by an automatic governor), and these valves adjust the flow of air to siphon up varying amounts of gasoline according to the speed and power requirements. No change or adjustment is required from summer to winter running, as the explosive mixture is further mixed and also warmed by the violent agitation it receives in the crank case, previous to its transfer to the top side of piston, and by the subsequent compression before the explosion takes place.

The maximum speed of this motor is 500 shaft revolutions per minute, which corresponds in frequency of explosions to 1,000 revolutions of a one-cylinder four-cycle motor; but the motor is made with two or three cylinders as well. It is cooled by water jacket around the explosion chamber.

A two-cycle motor with one, two or three cylinders is made under patents by Charles Sintz, one of the American pioneers in gasoline engine construction, which is remarkable not only for being a two-cycle motor but still more because it is reversible and self-starting. It is used extensively for boats.

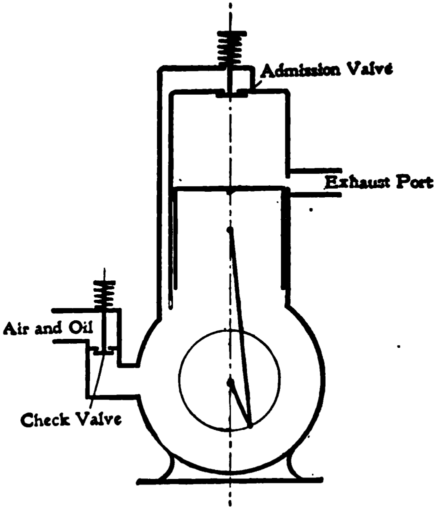


Fig. 25. Diagrammatic Section of Wolverine Gasoline Engine.

Fig. 25 gives a sectional diagram of the cylinders, and Fig. 26 a front view of a three-cylinder motor. Although this motor runs regularly at 1,200 revolutions per minute, the poppet valves by which the explosive mixture is admitted twenty times per second, are said to operate reliably The mixture is first admitted to the crank case, which is air-tight, and it will be seen from the diagram that the power stroke also compresses the

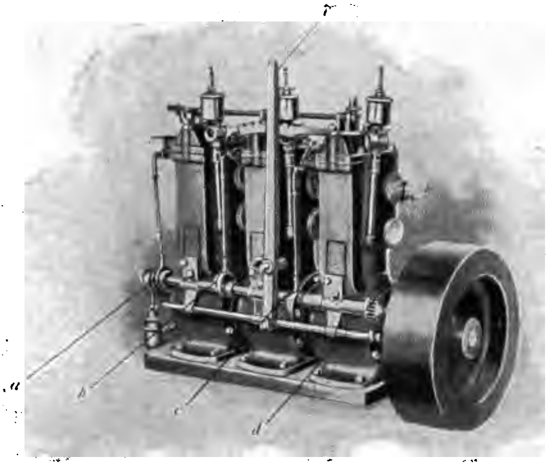


Fig. 26. Front View of Wolverine Gasoline Engine.

mixture, the back-action of the explosion keeping the admission valve in the cylinder head closed until the exhaust port relieves the tension of the burnt gases, when part of the mixture immediately enters into the upper part of the cylinder, whil the piston on its return travel simultaneously recompresses it and draws a new charge into the crank chamber.

The three crank chambers in a three-cylinder motor are distinct and separate, though the crank shaft runs through them all. Any air communication between them would make compression impossible, as the compression-work done by one piston would be neutralized by the suction strokes of the others.

The reversing of this motor is effected by means of the igniting device, which is actuated by three eccentrics, a, b and c, on the same shaft (Fig. 26). They may be turned by wheel d, which is operated by lever e.

By causing the ignition to take place before the piston has completed its back stroke, it is readily seen that the piston will be sent back and the rotary motion of the motor shaft will be reversed, unless the energy of motion is sufficient to carry the piston to the end of its compression stroke. In this case the reversal will take place at the next revolution. The illustrations are from American Machinist, September 14, 1899.

A gasoline motor hitched to a light load will ordinarily work itself up to a fantastic speed if left to follow its natural tendency to self-acceleration; still, this speed may be of short duration, because a point may be reached when premature ignition would be likely to result from overcompression of the explosive charge or overheating of the cylinder; or the admission valve would fail to act with the required promptness. Complete stoppage might be the result if the ignition were affected, but in most other cases the motor will settle down to a maximum speed interrupted by an occasional failure to accomplish the explosion. Most constructors consider it necessary to limit the normal highest speed somewhat below this maximum, and use for this purpose a governor usually operating on the centrifugal principle. Others simply reduce the exhaust port or valve to such a size that the resistance to forcing the exhaust gases into it, limits the motor speed automatically.

A governor may be designed to operate on the ignition device (preferably by retarding ignition), or on the gas admission mechanism, but the majority of modern governors are designed to act upon the exhaust valves.

One such governor device is described in the following, Fig. 27, being selected for description because it operates automatically at the highest desired speed, and may also be manipulated as a speed controller at lower speeds. The illustration shows an elevation and a plan view.

It is composed of the parts hereinafter described: a, a are the valves actuated by a tumbler, b, which is worked from the engine; c is the axis of the tumbler, which is mounted in a block which slides in a groove, d, formed in a cam, e.

The function of this cam is to raise the axis of

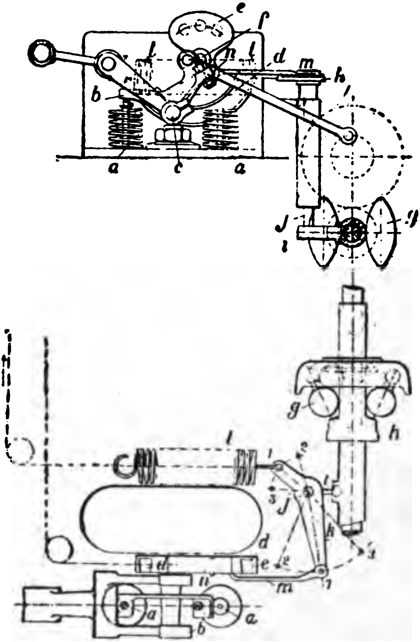


Fig. 27. Governor and Motor Brake Mechanism.

the tumbler or lower it, accordingly as the engine does more or less work. The tumbler, on being raised or lowered, presses more or less upon the valve spindles and alters their travel, for this cam turns about a pivot, f, located slightly to the right of the center of the cam groove d, and the arrangements are such that when the sector is in its extreme position on the right, the center of the groove is at its lowest position; the axis of the tumbler is then in its lowest position, and the engine is working at its maximum.

If the engine is working too quickly, the ball governor g pushes the cam to the left and causes the tumbler axis to be raised.

The variations in the travel of the valves are continuous by reason of the sector or cam being curved, and the valves can pass from their maximum opening to zero, that is to say, to stopping the engine.

The governor g, when the speed increases, causes the sleeve h to be lowered and to press upon the lever i, fixed upon a spindle j, which carries at its other end a two-armed lever k, one arm of which is attached to the spring l, and the other joined to a small connecting rod m, pivoted to the sector e at n. The spring l has for its object to limit the action of the governor and allow a power varying from zero to the maximum to be assigned to the engine by means of its greater or less tension.

If the spring l be fully stretched the lever j will be brought into the position 2-2 (the position 1-1 of the lever being considered as the mean position).

Consequently the cam e is displaced by the connecting rod m towards the right, in such a manner that the block carrying the axis c of the tumbler turns into its lowest position corresponding to the maximum travel of the valves, that is to say, to a maximum power of the engine.

If the spring l be completely relaxed the lever k will come into the extreme position 3-3, and the axis of the tumbler will correspond to the minimum travel of the valves, and each phase of tension of the spring l will correspond to a given power of the engine. Maximum tension corresponds to the greatest power, and no tension to zero.

The governor can only act when it has overcome the tension of the spring, so that the power of the engine can be regulated in advance by regulating the spring by hand, and the governor has for its object only to govern the speed of the engine, as soon as the resistance to be overcome is less than that which corresponds to the tension of the spring.

The tension of the spring may be adjusted as desired, either by a hand lever or by a pedal.

A motor which has called forth a great deal of comment in France is that illustrated in Figs 28 to 32. It is designed by Marius Marmonier, of Lyons, France, and furnishes a highly interesting subject for study, because it exemplifies more completely than any other motor, American or European, the modern efforts for rendering the explosion motor as tractable and flexible as the steam engine, while retaining the compactness

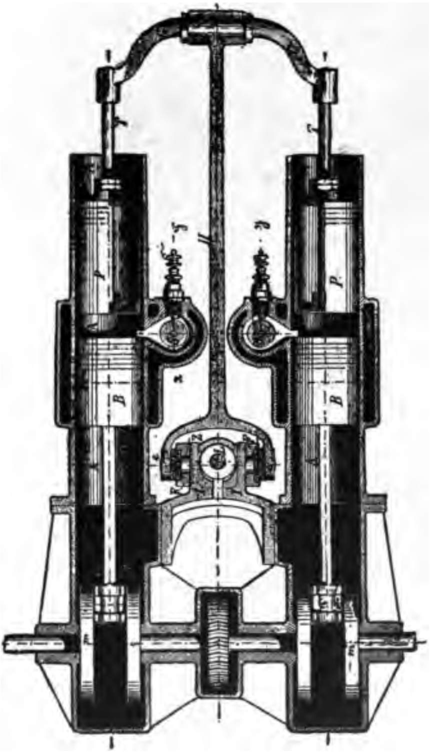


Fig. 28. Plan and Horizontal Section of Marmonier's Motor.

and enhancing the economy of the ordinary gasoline motor. It is described as follows:

Marmonier tries to obtain as large a variation of power as possible by varying the capacity of the combustion chamber. The quantity of burnt gases remaining in the cylinder chamber after each exhaust stroke is reduced or increased in direct proportion to the volume of fresh vapor admitted, so that at the moment of the subsequent explosion, the proportion of fresh and burnt gases, as well as the compression, remains the same over the entire range of variable admissions.

Cylinders A are open at both ends. The pistons B are connected by the shanks b, and the cranks m to the motor shaft. Counter pistons P are connected by the rods T and the rigid yoke G. The disk D, geared to half motor speed, carries on each of its faces a cam, d, which regulates the to-and-fro movements of roller studs E, which through rods K control the slide F, imparting to it an oscillating movement during the admission and compression strokes. C is a bolt formed in two parts, which may be moved up and down in the slotted sides of the slide, being actuated by the adjusting screw M. A nut, N, working upon the screw M, engages the bolt C with two pins, so that the nut moves up or down with the bolt C when the screw M is rotated. The yoke I carries the fixed pivots Z, around which the slide F oscillates, and also the standard L, which is connected with the screw M by means of a Cardan joint

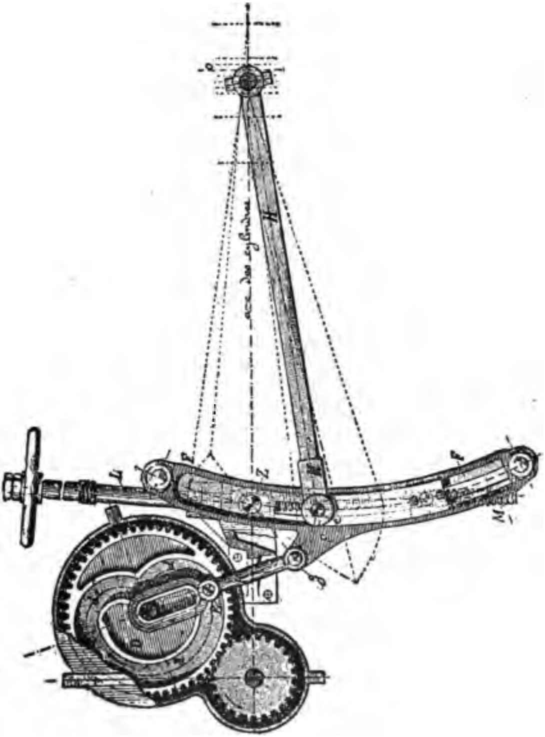


Fig. 29. Details for Controlling the Counter Piston.

concentric with the axis of the fixed pivots Z. The rod H is forked at one end, and attached to the projecting ends of bolt C, following the displacements of the latter along the slide; at the other end it is jointed to the yoke G. The rods K, above mentioned, are jointed at their lower extremity to the lug g, which is integral with slide F. R is the automatic admission valve, and S the exhaust valve, which is controlled by the cam J on the half-speed shaft.

The motor operates as follows, only one of the cylinders being considered, as the operation of the other is the same:

Suction stroke. The cam d displaces studs E which cause slide F to oscillate from right to left. If bolt C is so placed that its axis is on a line with the pivots Z, rod H and the counter-piston P will remain unmoved. There will then be full admission of fresh gas equal in volume to that displaced by the piston stroke. But if C occupies a position lower on the slide, rod H causes counter-piston P to move inward in the cylinder at the same time as piston B travels its suction stroke, and by this action the quantity of fresh gas admitted will be reduced. The lower C is placed on the slide the greater will the reduction be, and when C is at its lowest possible position the stroke of the counter-piston will equal that of piston B, and no fresh gas will therefore be admitted. If C, on the other hand, is above pivots Z, the slide will oscillate in the other direction, and the counter-piston will move outward, enlarging the space in the cylinder and adding its own suction stroke to that of piston B.

Compression stroke: The studs E continue to roll on cam d; the slide oscillates from left to right (if previously from right to left), and the counter-piston returns to its initial position.

Fower stroke and exhaust stroke: The studs E roll on the concentric portion of cam d, and slide F and counter-piston remain stationary. Piston B makes the power stroke and expels the burnt gases.

Besides the effect of the counter piston movement upon the gas admission, it is to be noted that the space between the pistons is reduced when C is low on the slide, and that, therefore, the volume of burnt gas remaining in the cylinder after the expulsion stroke is correspondingly reduced, and that the subsequent compression of the smaller gas charge admitted remains unchanged because it takes place in a correspondingly smaller space. In other words, the quality of the charge remains always the same, the slide being so shaped as to bring about this result even at the extreme positions of C, whether below or above the fixed pivots Z. At the lowest position, when there is no gas admission at all, the counter-piston abuts against piston B, and follows it during the suction stroke.

By changing the form of the slide it is seen that the motor may be adapted to vary the compression according to the volume of the gas charge, if this should be considered desirable.

Generally speaking, the slide performs the same functions as the throttle in steam engines, and the mechanism described should therefore be well adapted for stationary motors used in the industries, the power being readily adjusted to the maximum work required in each case.

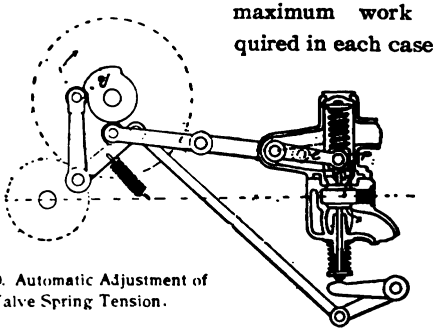


Fig. 30. Automatic Adjustment of Valve Spring Tension.

In the above explanations no cognizance is taken of the "dead spaces" existing in all motors; the pipes for admission and exhaust leading to the corresponding valves or parts. These represent in the motor referred to one twenty-fourth of the cylinder space, and modify slightly the exactness of the explanations. But there is no real necessity for dead spaces, as the valves might be placed in the head of the counter-piston.

When the motor is worked with very small charges, it follows from the very small volume of the gas exploded that the burnt gas, after the piston has finished its power stroke, may be under less than one atmospheric pressure, which condition would result in opening the admission valve and admitting a certain quantity of explosive mixture in the cylinder when not wanted, only to have it expelled at the next piston stroke as a pure loss and cause of unnecessary odor. Fig. 30 shows the arrangement made to obviate this undesirable result. During each period when the exploded gas is expanding, the spring which holds the admission valve to its seat is stiffened so that the pressure on this valve will exceed that on the exhaust valve, thereby causing any suction that may take place to take effect through the latter. The cam j, which controls the exhaust valve, controls also, during the power stroke, the lever I, which presses upon the collar p, mounted upon the valve stem, and compresses the spring.

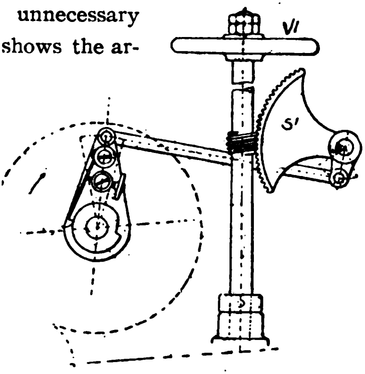


Fig. 31. Ignition Regulating Device.

In Fig. 31 is shown a device for this motor, especially intended for its application to motor vehicles. Its object is to advance the time of ignition automatically in proportion as the vapor charge is increased, the exact design of the device having been determined by experiments showing what time of ignition is most suitable for any given vapor charge in order to obtain the highest power efficiency. When turning the control-wheel V^1, which regulates the vapor admission through the screw M, the sector S^1 is also turned on its pivot, and it, in turn, controls the ignition device.

It will be noticed that the entire motor mechanism forms an organism which may be controlled in all its functions by a single mechanical element, the control-wheel V, fixed at the top of standard L. By manipulating it the driver regulates the power and speed of the motor as well as the fuel consumption, adapting these factors to the work desired. Nothing prevents, however, the control of the ignition to be severed from the rest of the organism, and this disposition might be preferred by very skillful drivers.

In the foregoing the supposition has been that a carbureter supplied the explosive mixture in gaseous form to the cylinders. Fig. 32 shows a supplementary device for use if it is preferred to feed the hydro-carbon into the cylinder in liquid form.

It consists in a pump which automatically reduces the liquid fuel supply in proportion as the air admission is reduced. This pump has two pistons, one with a fixed stroke and actuated by the

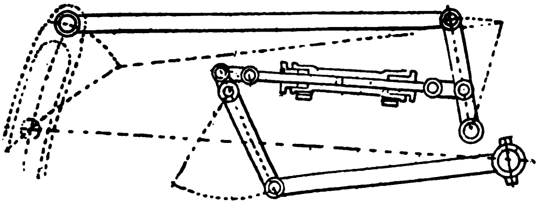


Fig. 32.

slide F during the suction and compression strokes, and the other with variable stroke and connected to the counter-piston rod as shown in the illustration. The operation is entirely analagous to that of the cylinder piston and counter-piston, and requires no further explanation.

CHAPTER VII

PETROLEUM MOTORS AND VEHICLES

To be able to substitute heavy kerosene for gasoline as the source of power for motor vehicles has always appeared very desirable, partly because kerosene is more readily obtained in out-of-the-way localities, and partly because it may be handled more carelessly before it is placed in the fuel receptacle in the wagon. After once placed there the kerosene offers no special advantages, except in the case of leaks, which, with gasoline, may be a source of accidents, or with constructions that admit the possibility of subjecting the gasoline vapors in a carbureter or tank to high pressures that might cause ignition and explosion.

There are several stationary motors on the American market in which the gas mixture may be generated from kerosene, and it is generally expected that one or two of these will be heard from in connection with automobile traction before the year 1900 shall have passed.

The main obstacles in producing successful kerosene motors in the past have been due to precisely that property of kerosene which renders it desirable and safe for motor purposes, namely, the high temperature required for making it give off a readily ignitable vapor with the rapidity required for motor work.

The vaporizer arrangement most commonly employed for overcoming this obstacle has consisted in the attachment to the motor of an air-compression pump by the pressure from which kerosene was forced in a fine spray into a heated vaporizing chamber before being admitted to the combustion chamber.

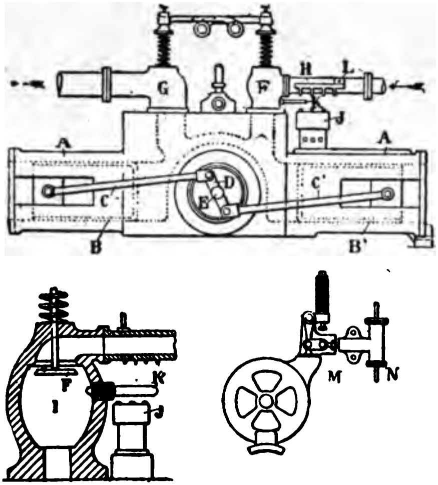


Fig. 33. The Koch Kerosene Motor.

The first practicable motor vehicle operated with a kerosene motor was invented by C. M. Koch of Paris. His motor (Figs. 33 and 34) is composed of two vertical or horizontal cylinders, A, A1, between which is a wide space. Two pistons, B, B1, move in opposite directions and symmetrically in these two cylinders. The connecting rods C, C1 actuate a crank D on a shaft E.

The admission and exhaust by the valves F and G respectively are in the space between the two cylinders. There is only one admission and one exhaust for the two cylinders.

H is a tube by which air enters the explosion chamber I; the liquid kerosene also enters the tube H by the pipe L, and passes into the chamber I, mixed with air. J is a lamp heating the tube H and the ignition tube K. N is the point of admission of oil into the pump (Fig. 34).

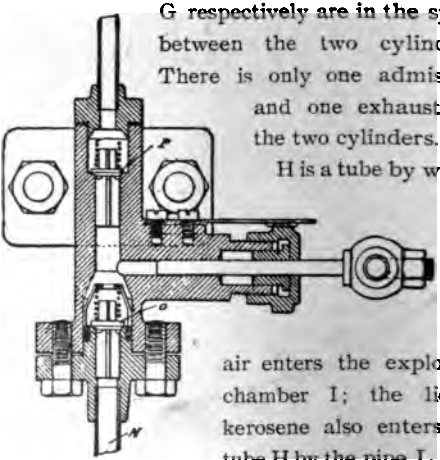


Fig. 34. Details of Pump Valve.

This pump is operated by the motor by means of a system of levers which can be adjusted by springs. It works as a force pump, owing to the arrangement of the springs O and P, which actuate its valves and its piston. The valves and piston may be either vertical or horizontal; but if the piston is vertical the valve springs are horizontal, and vice versa.

The vaporizing chamber is in one with the explosion chamber, and is of spherical shape, in order to have as little heat radiation as possible in proportion to its capacity. Before the air and the kerosene enter the vaporizing chamber both are heated by the flame of the lamp J, which also heats the ignition tube K. The latter, being closer to the flame than the tube L, is heated most, and enters through non-conducting material into the vaporizing and combustion chamber. It presents a comparatively large heated surface in order to facilitate ignition and propagate the flame to all portions of the combustible mixture with the greatest possible rapidity.

Among the American kerosene motors, the Secor may be given as an example of latest construction.

It was first perfected with a view to furnishing a cheap, convenient and absolutely uniform motive power for driving dynamos in isolated electric plants, and, this being accomplished, has been adapted to automobile purposes, the requirements for carriage use consisting mainly in new means for the suppression of vibration, which presents a more difficult problem when the motor is carried on a movable support than when it is used for stationary work. The stresses to be balanced are those caused by the expansion of the gases against the cylinder walls, those due to the change from the reciprocating motion of the piston to the rotary motion of the shaft, and those due to centrifugal effects. This adaptation is said to have been successfully consummated in the latter part of 1899.

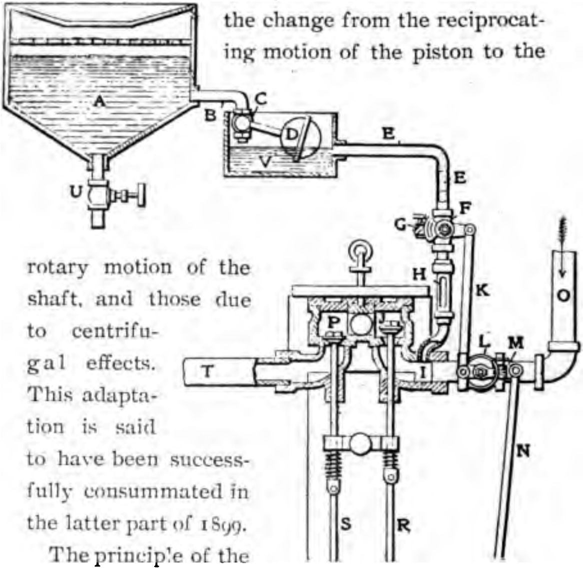


Fig. 35. Fuel Feed Secor Kerosene Motor.

The principle of the stationary motor has been described in American Machinist, with reference to the diagram herewith produced, Fig. 35, in part as follows:

"From the fuel tank A, having the emptying cock U, the oil descends through a curved pipe B and the valve C, which is governed by the float B, to the constant-level tank V. The object so far is to obtain a constant gravity head for the flow of fuel, which next descends through the bent pipe EE to the fuel admission valve F, whence it flows downward through the brass-cased glass sight-tube H into the air-admission bend I. The air admission to the cylinder is controlled first by a butterfly valve, not shown, but placed in the vertical air-admission pipe, through which air is sucked downward by the action of the engine piston. . . . Next below the butterfly valve is a bored seat, in which is placed a segmental rocking valve L, which is under control of the governor, and is the effective member of the air-admission controlling mechanism. The valve F is controlled by the rod K, pivoted to a lever on the horizontal actuating arm M of the valve L. The governor rod N is pivoted to the right-hand end of M. This makes a single governor rod control both the oil admission and the air admission. To provide an independent adjustment of the volume of either the air or fuel admitted, a micrometer adjustment is provided at G for the oil valve F, and at M for the air valve, so that precisely such relative volumes of air and oil can be delivered together as are required to form a perfectly combustible mixture.

"The action of the governor is thus made to deliver the same proportionate combination for every charge, the regulation being effected by increasing or decreasing the volume of this mixture for a single cylinder charge. Throttling the total volume of the charge very rapidly reduces the cylinder pressure produced by the firing of the charge, although every charge, no matter what its bulk may be, is perfectly burned. Under these circumstances the governor action is very prompt. The Secor motor is believed to be the first to place both the fuel admission and the air admission under control of the governor.

"Referring again to the diagram, J is the admission valve, operated through the rod R, from a cam of the usual type employed in explosion motors working on the Ottocycle. The rod S is similarly operated, and drives the exhaust valve P, which opens communication between the cylinder and the exhaust pipe T, leading into the open air.

"The ignition is electric. The current from six cells of battery is led through a Rhumkorff coil to a jump-spark igniter, screwed into the top cover of the compression chamber.

"The Secor motor is water-jacketed, compression chamber and cylinder both, and the engine is remarkably cool when in operation."

Another kerosene motor is the Capitaine, which is made in this country, but was originated in

Europe. It is remarkable by being one of the few hydro-carbon motors in which the ordinary form of direct piston connection with the cranked shaft has been abandoned.

The fuel (ordinary kerosene, specific gravity about 0.80) is forced into the cylinder by a diaphragm pump which operates without valves. The flexible diaphragm of this pump is worked by a cam on a secondary shaft, which in turn receives its motion through an eccentric on the main shaft, and a push-and-pull ratchet. It makes one revolution to four revolutions of the main shaft.

The governor is based on the varying degree of compression in a small auxiliary cylinder, in which a piston is worked from the secondary shaft mentioned above. Changes in speed of the engine and the consequent changes in speed of the governor piston, change the pressure in the governor cylinder, which has a fixed outlet. When the speed of the engine exceeds a certain limit, thus raising the pressure in the governor cylinder above that for which its outlet valve is set, this outlet valve is closed and the pressure in the cylinder is greatly increased by the continued advance of its piston. This increased pressure is used to disengage a push-and-pull ratchet, which communicates the motion to the cam of the fuel pump, thus stopping the supply of fuel until the engine speed has fallen to the normal.

Lubrication is made positive by the use of a small force pump operated from the secondary shaft, which forces oil to every bearing and to the cylinder every second revolution of the engine. The ignition is by hot tube.

Part II

Steam-Power Vehicles

CHAPTER VIII

ADVANTAGES AND DISADVANTAGES OF STEAM AUTOMOBILES IN GENERAL—THE STEAM RENAISSANCE IN AMERICA

When mention is made of steam motor vehicles in the United States it is almost invariably the light-weight pleasure carriage that is thought of, while in England and France the steam vehicle idea until very recently has been exclusively associated with a mental picture of heavy freight wagons or omnibuses; and this state of ideas indicates correctly the development that has taken place.

The steam vehicles of Europe have been evolved in accordance with the tenets of professional tradition. The engineering data gathered during a century and a half of steam engine practice have been faithfully consulted by the European designers of modern steam vehicles, and the result has been that they found it impossible to fully emancipate their productions from the drawbacks in the way of heft and cumbersome heating methods which attached to earlier types and disqualified them for any but comparatively slow work on common roads.

In the United States the problem of steam automobiles was attacked in a revolutionary manner and in defiance of precedents by a single-handed pioneer, S. H. Roper, upon whose work all the progress is founded which, during the past few years, has made the light steam carriage the most distinctively American contribution to the solution of the problems of automobile locomotion.

In regard to Roper's work the following data extracted from an illustrated biographical sketch by R. I. Clegg, in American Machinist, May 18, 1899, are of interest:

"The late Sylvester Hayward Roper, of Roxbury, Mass., became interested in automobile investigations away back in the fifties; and he thus early realized the bitterness of the storm that awaits the pioneer who interferes with the established rules of the road.

"So far as a suitable power was concerned, Mr. Roper's hopes were centered upon steam, and his long experience simply served to strengthen his conviction. Several vehicles so equipped were built by him before 1870, but there was so much opposition to his right to use the public streets that he finally desisted, as far as actual manufacture was concerned, and retained one machine solely for his own personal use and experiment. Along in 1869 or 1870 he constructed a successful steam velocipede.

"This velocipede was in use for some twelve

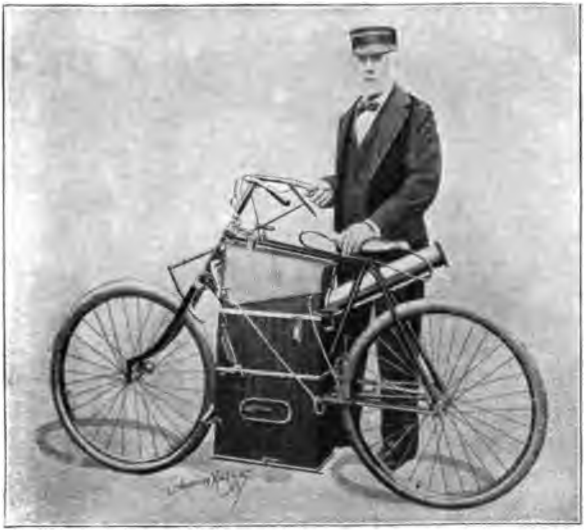


Fig. 36. S. H. Roper and His Steam Bicycle [Left Side].

years when Mr. Roper built a four-wheeled carriage—a double-seated sulky to carry two persons. The cylinders of the engine were located in the smoke-stack, and all but the lower part of boiler was concealed in the body of the vehicle. The sulky was afterwards sold to a Boston merchant, who intended to apply an oil-fuel system in place of the coal grate already in use. Business cares prevented any great progress in this line, and the machine next turned up in New York City as the nucleus of a proposed autocar company, and later still, I understand, the machine went south, where I have been unable to trace it further.

"At seventy-three years of age Mr. Roper took up the steam bicycle once more.

"He took a Columbia bicycle, removed the cranks, chain, hanger and rear wheel bearing, and in the diamond frame attached his outfit—boiler and engine—as an integral part of the structure. Fig. 36 shows the reconstructed bicycle; and the inventor, who holds the wheel in position. In the other view, Fig. 37, the bicycle is seen self-supported by the rod hinged to the boiler.

"The engine is a single cylinder, 1¾ inches diameter by 4-inch stroke. A D-slide valve is driven by an overhanging pin outside the engine crank. From the other end of crank shaft is driven the feed pump. The pump has a stroke of 1 inch, and the plunger is ¼ inch diameter. The feed water is contained in the tank, immediately under the rider, and absorbs heat coming from the smoke-stack and boiler. Before entering the boiler the feed water passes through a coil heater in the smoke-stack. Inclined glass water columns to tank and boiler allow the rider to keep track of the supply. A valve on the suction pipe permits the supply to be nicely regulated for ordinary conditions of travel, and a hand pump seen near the bars enables an increased amount to be provided at pleasure. Part of the products of combustion passes around the cylinder to the stack, which also receives the exhaust from the engine. Two cords control both boiler and engine; a damper in smoke-stack, as well as the throttle valve, being so connected with the handle bars. On each side are the foot-rests, at the forward end of the fire-box.

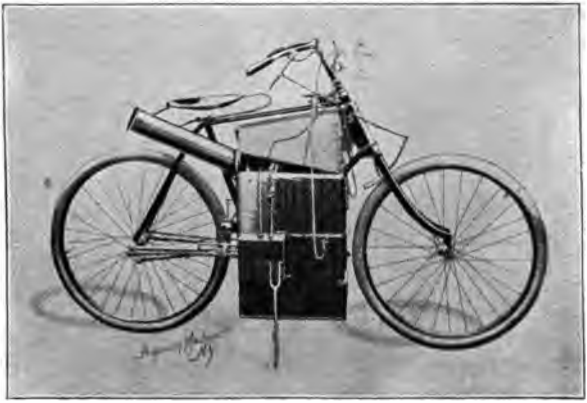


Fig. 37. Roper Steam Bicycle [Right Side].

"Boiler is rectangular, 8 inches deep, 20¾ inches high, 15½ inches long, containing 84 steel tubes. Tubes are 10½ inches long by 9-16 diameter. I am unable to give exact thickness of tubes; they are very thin; probably .02 inch. A space of ½ inch is allotted to the water jacket around the firebox. From base of grate to base of flues is 10 inches. The boiler is encased in asbestos and mahogany.

"Franklin coal was used for fuel, and once charged the tiny grate was ample for a seven-mile trip. Mr. Roper has gone several times from his home in Roxbury to the Yacht Club, in South Boston (City Point), cleaned the fire and replaced the same coal, got up steam and returned home—three and a half miles each way.

"About 160 pounds of steam was carried on level roads. For hills this pressure would be increased to 225 pounds. The boiler had been tested to 450 pounds. Total weight of machine loaded ready to start was 165 pounds.

"It will be remembered that Mr. Roper died suddenly at the Charles River Track, Boston, at the close of a test of the bicycle against the Butler Brothers' tandem. He had then made three consecutive thirds (⅓) of a mile in 42, 39, and 37 seconds respectively. The cause of Mr. Roper's death was sclerosis of the arteries, from which he had suffered for some two years, the malady undoubtedly being greatly intensified by the excitement attendant upon the remarkable speed developed at the exhibition.

"Notwithstanding the showing already mentioned, the inventor did not consider the bicycle the finished product he desired, and was preparing plans to try petroleum fuel, etc."

When looking into the reasons for the great activity in designing and manufacturing of light steam carriages which sprung up in the New England States as soon as the first few of Roper's followers had attained a measurable practical success (first publicly demonstrated at automobile contests held in Charles River Park, Boston, November, 1898)—an activity that might seem strange in the face of the acknowledged superior economy, compactness and prestige of internal-combustion motors—a strong sidelight is shed over the question by considering the unreasonable demands that are usually made in regard to gasoline motors and their work. "What we want in a gasoline motor," wrote an English devotee of automobile sport in The Autocar, in 1899, and won general acclaim for his felicitous way of putting the demands, "is an engine which fulfills the following conditions:

"1. It should be small and of light weight.

"2. It should run at a reasonable speed.

"3. It should be free from vibration.

"4. It should be possible to vary the speed and power, at will, from nothing to its maximum, and it should give its full torque at any speed.

"5. It should not be necessary to have either reducing or speed gear.

"6. It should be reversible.

"7. It should stop when the car stops, and start up in a moment upon the mere movement of a handle.

"8. Its parts should be few and easy to repair.

"9. When running it should require little attention, and that little unskilled."

All these requirements, with the possible exception of 8 and 9, are fully met in the light New England steam engine for motor vehicles, and thus it fills in a measure the "long-felt want" of those who have become impatient with the shortcomings of the average gasoline motor.

Hereto comes that small steam engines may be produced cheaply and in quantity in any shop well equipped with modern automatic machine tools, while the production of an original hydro-carbon motor and vehicle calls into requisition a formidable amount of foundry work, drop-forging and special painstaking and time-consuming labor with hand tools.

The advantages of the light steam engine for motor vehicle work are very conspicuous from an economical as well as from an esthetic standpoint.

They are equally appreciated by the maker and the user, if the latter is one who is qualified by temperament and education or training to take proper care of the instrument placed in his hand, but they are accompanied by certain disadvantages which sooner or later make themselves felt. The mechanism is not nearly as robust as a well-made gasoline motor, at equal weights. It is bulkier, and leaves less space in the automobile for cartage. The boiler is likely to be damaged seriously if the operator neglects to watch and attend to certain of its functions, especially water feed. Its exhaust, while not ordinarily visible in warm weather, is objectionably conspicuous in cold weather. Its water supply must be frequently renewed if the engine is put to continued hard work.

In spite of these shortcomings, which are not equally pronounced in all makes, the light steam pleasure carriage is making rapid headway in the favor of a large class of people in this country, whose requirements it seems to fill better than either the electric or hydro-carbon type of automobile, and it is also finding a ready sale in European countries.

Putting the case more briefly than accurately, all the American light steam vehicles may be described as combinations of a gasoline stove with a small-sized ordinary engine fed from a tubular boiler in which the tubular feature is exaggerated in order to generate steam with extraordinary rapidity and in prompt obedience to variations in the fuel supply.

In most styles of these vehicles the fuel feed is regulated automatically by the steam pressure, in order to obviate all danger of explosion from high pressure when the machine is placed in unskilled hands. In some of them the boiler feed (or height of water in boiler) is also automatically regulated. And it is toward the perfecting of these automatic regulations that the efforts of most designers are directed, although much is also being done with a view to making the exhaust invisible in all kinds of weather, or suppressing it altogether by means of a condensing apparatus, thereby also economizing the water supply.

CHAPTER IX

DESCRIPTION OF A TYPICAL STEAM PLEASURE CARRIAGE

In the following is given a nearly complete description of one of the best-known types, namely that designed by George E. Whitney, of Boston, of which the main features are embodied in the productions of several independent manufacturing companies. This vehicle may be taken as typical of the whole class, inasmuch as the designer was among the very first to follow in Roper's footsteps.

The characteristic special features of other styles will be more briefly described and illustrated hereafter.

The illustrations from Fig. 38 to Fig. 48 thus all apply to the Whitney type.

The boiler, Figs. 38 and 40, in the style illustrated is a cylinder about thirteen inches high and 15 inches in diameter, containing about 300 vertical one-half inch tubes, which serve as fire flues, the water and steam filling the interstices between them. Copper is used because tubes of this material may be readily flanged at the joints with head and bottom of the boiler without danger of rupture, and are also less liable than thin steel tubes to be weakened by corrosion. In addition,

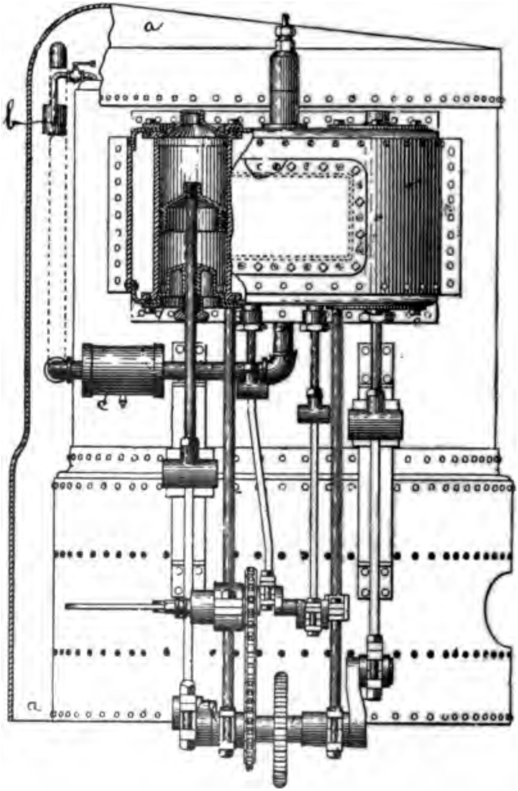


Fig. 38. Boiler, Waterleg and Engine.

the use of copper tubes makes the construction safer in case a neglectful operator should allow the boiler to become overheated (through failure of the automatic regulation). The copper tubes would then be expanded and elongated more, by the heat, than the steel of the cylinder, and the joints of flues and boiler head would be disrupted, allowing the steam to escape, before the danger point would be reached.

In taking steam from the boiler to the engine a

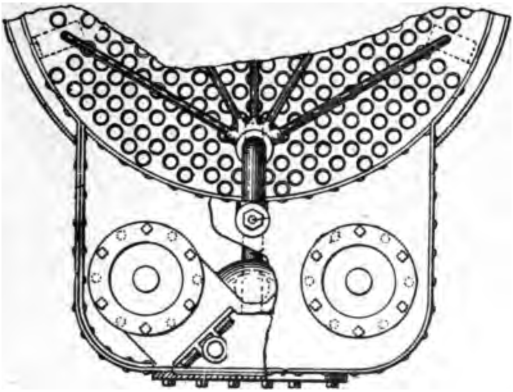


Fig. 39. Steam Intake.

number of pipes are used instead of one (see Fig. 39), each having a disk, d, between its opening and the interior of the boiler. By this provision foaming or priming, which occasionally results from an admixture of lubricating oil or similar impurities in the water, will not interfere with the operation of the engine, as might be the case if the steam were taken through one pipe only.

The engine—a pair of single-expansion cylinders—is mounted on the boiler by brackets secured to the boiler shell and the waterleg surrounding the firebox, the cylinders are surrounded by a jacket

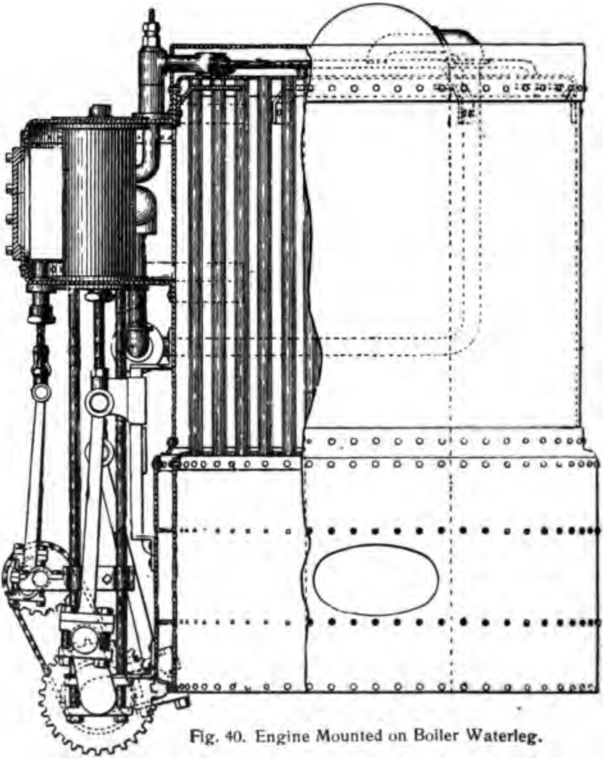


Fig. 40. Engine Mounted on Boiler Waterleg.

which prevents condensation. The gaseous products of gasoline combustion are carried off by a flue or hood that covers the top of the boiler (Fig. 38, a), and is carried down its side and discharged at the bottom, passing away from the occupants of the vehicle. In case the natural draft is insufficient, it is possible to increase it by a steam-jet, b, pointing downward in the flue.

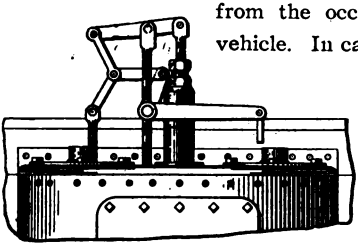


Fig. 41. Toggle-Joint Throttle Lever.

This hood, or flue, serves a double purpose. The pipes that deliver the live steam to the engine are placed in this flue, which keeps them heated, so that they will deliver a dry, super-heated steam to the engine. The exhaust steam, after leaving the engine, passes through a muffler, C (Fig. 38), and is delivered into the top of the hood, where it comes in contact with the burned gases that thoroughly dry it; thus the exhaust is barely visible except in cold weather.

Connected to an upright adjoining the throttle valve-stem is a compound lever having a toggle connected to the throttle valve and an upright placed in the cylinder head (Fig. 41), the whole forming a very sensitive system for controlling the engine.

The water feed is controlled in a simple but novel manner. A pipe (Fig. 42) opens into the top of the boiler at d, and connects with another pipe, e, of larger diameter, which extends horizontally at the normal water level. At the other end of this enlarged pipe is connected a return pipe connecting with the lower portion of the waterleg, so that the water in pipe f may readily find the same level as in its connections. While it finds this level freely, its circulation is not rapid, and its temperature is lower than the water and steam in the boiler. The pipe e is provided

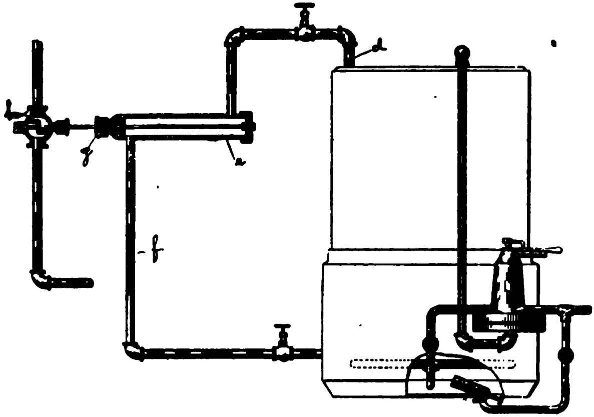


Fig. 42. Diagram of Water Feed.

with a stuffing box, g, through which passes an expansion rod secured at its inner end, and at its free end attached to a valve, h, in the feed water supply pipe; the latter connects the water tank with the boiler. This is fed by a pump (not shown) that is in constant operation, being worked by an eccentric on the driving shaft. When the water is at the normal level and standing in the pipe e, the expansion rod will keep the valve h closed; but when the water level falls, live steam passes into the pipe e from the boiler, and its increased temperature causes the expansion rod to open the valve h, thereby admitting additional water and restoring the normal level of the boiler. The valve is closed as soon as this point is reached by water of a lower temperature.

The frame of this vehicle is of the side-bar type and made of steel tubing with cross-bars, giving a light and rigid frame which supports the body on three elliptical springs (Figs. 43 and 44). The boiler and engine are housed in the body of the vehicle and mounted at an angle that allows the use of a simple and flexible method of transmitting power to the drive wheels.

Steering is accomplished in the usual manner by steering-knuckles having short arms connected by a rod, which in turn is connected by another rod to the standard of the steering lever; the latter is secured to the front of the body of the vehicle just inside and at the middle of the dashboard. The same lever is used for controlling the throttle valve in a simple and effective manner. As shown in Fig. 43, the steering lever is curved at a point near the top of the dashboard, and ends in a spade handle; the lever is hollow, and a flexible shaft connecting with the handle at one end passes through it and connects with a segmental rack, a, which engages a pinion on the rod connecting with the throttle valve h; the latter can be controlled by the slightest movement of the spade handle, regardless of the angle of the steering lever. Another function of this lever—or, as it should be called, controller—is that of operating a cylinder, C, Fig. 46, having a steam connection

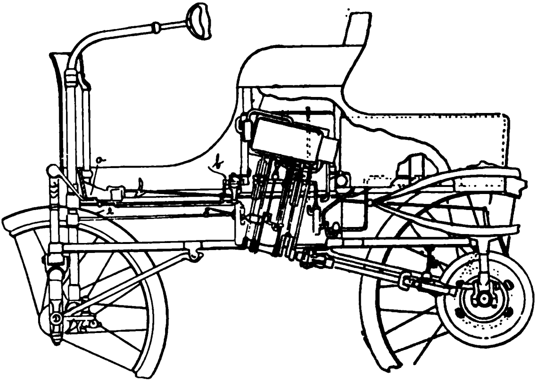


Fig. 43. Driving and Steering Gear. Side View.

with the boiler, thereby actuating a piston having a rod connecting with the hand brake d, Fig. 43, so that when the steam is shut off from the engine it is admitted to the brake cylinder, and the vehicle is stopped. The admission of steam to the engine releases the steam from the brake cylinder, and the vehicle is started. The segmental rack (a, Fig. 43) engages a pinion on the rod which connects with the brake cylinder; this brake has a connection with a pedal that is placed in the bed of the body so as to be reached easily with the foot of the operator; this permits the brake to be applied in case the steam cylinder fails to act.

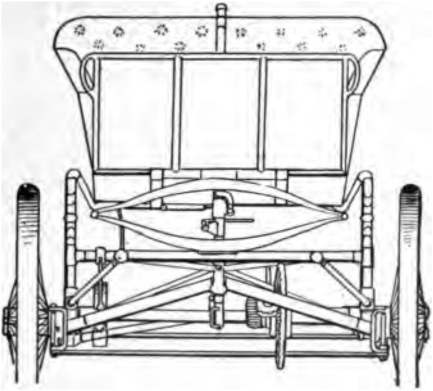


Fig. 44. Front View of Steam Vehicle.

The method of reversing the engine is as follows: It is accomplished with the controller by pulling the spade handle toward the operator. That portion of the steering lever just below the body of the vehicle (e, Fig. 43) is connected to a rock shaft having an arm that is connected by a rod to the link which forms the reversing mechanism. When the controller is in its normal position, the vehicle will go ahead.

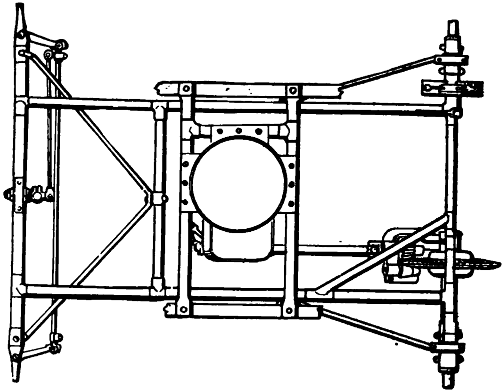


Fig. 45. Plan of Frame, Steering and Driving Gear.

The method used for transmitting power from the engines is by a shaft having two universal joints (Figs. 43 and 45). On the opposite end of the shaft is a beveled pinion which engages with a differential gear on the driving axle (see Fig. 45). The universal joints permit both vertical and lateral movements of the vehicle body (due to the action of the springs) without interference with the working of the motor. On the opposite end of the driving axle is placed the hand brake, controlled by foot or steam pressure.

The boot of the vehicle (Fig. 46) holds the water tank. This is divided into two compartments with an air space between them, but connected by a pipe with a check-valve permitting the water to pass from the rear tank to the front one. The rear tank contains a smaller tank for liquid fuel, which is generally submerged in the water.

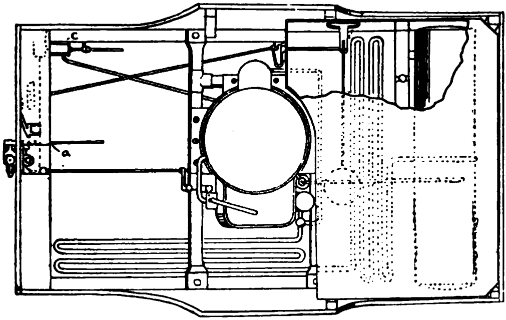


Fig. 46. Showing Water Tank and Connections.

A pipe from the fuel tank passes through the water tanks and out to a fuel feed regulator, the description of which is here omitted as being of less interest than the corresponding device in other steam vehicles.

The exhaust steam, after leaving the muffler, passes through a series of pipes beneath the floor of the vehicle; then into the front compartment of the water tank through another series of pipes;

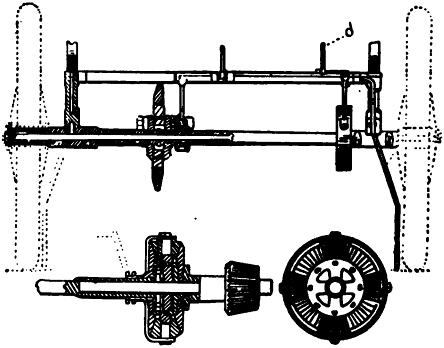


Fig. 47. Differential Gear and Rear Axle; also showing Exhaust Pipes.

then leaves the tank and forks into two pipes which lie along the rear axle and bend downward (Fig. 47) so as to empty out near to the ground It can also be disposed of by returning it from the muffler direct to the flue for burnt gases, as before mentioned.

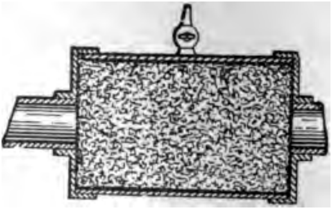


Fig 48. Muffler.

The muffler (Fig. 48) consists of a metal cylinder in which is placed a wire envelope containing a quantity of fibrous matter used for breaking the steam into minute particles without causing back pressure.

CHAPTER X

VARIATIONS IN STEAM VEHICLE CONSTRUCTION—STEAM FREIGHT WAGONS AND OMNIBUSES

In Baldwin steam vehicles the fuel is either gasoline or kerosene, and the boiler is of upright fire-tube type, somewhat similar to the Whitney. To start the engine a hand pump is used to pump air into the gasoline tank, so to give the requisite feed pressure to the burner. A small receptacle is filled with wood alcohol or gasoline, and after being lighted is set under the burner to give it the necessary initial heat to vaporize the gasoline. The burners are lighted from this by the turning of a cock, and after a brief time to get up steam the vehicle is ready to operate.

The steam pressure regulates the supply of fuel automatically by means of a diaphragm valve (see Fig. 51). In case the vehicle is left standing the supply of gasoline is cut off from one or two of the three burners as the steam pressure rises, and the third supplies merely enough heat to enable the vehicle to be started again at a moment's notice.

The engine is of the two-cylinder double-acting vertical variety. The cylinders are 2¼-inch bore and 4½-inch stroke, and lie snug up against the boiler. The exhaust ports open direct into a jacket surrounding the entire cylinder, giving at once an exhaust with little back pressure and a steam jacket for the cylinder.

The exhaust steam is carried from this steam jacket to the combined muffler and condenser, and then passes through the fuel tank in the shape of hot water, maintaining a sufficient pressure in the tank (if the fuel be gasoline) to avoid the necessity of any hand pumping. Thence the hot water passes to the water cooler in the dash, which is composed of a number of horizontal tubes through each of which the water is compelled to pass before it is returned to the supply tank, to be again sent on its cycle of functions.

In case it is required to call upon the engine for an unusual amount of work, as in the case of continued hill climbing, or of traversing very bad roads, and there is a consumption of a greater amount of steam than the condenser is able to take care of, the necessary portion of steam is automatically shunted off into a tube which coils over the upper openings of the fire tubes of the boiler, is there superheated and passes below into the burner, where it meets a forced draft, after which it passes off with the products of combustion in the shape of an invisible exhaust, after having added to the steam-producing power of the boiler.

The Baldwin runabout (Fig. 49) weighs 750 pounds, while a similar vehicle, known as the locomobile or Stanley steam vehicle, which resembles the Whitney in boiler and engine design, weighs less than 400 pounds; but, then, neither of the latter vehicles is provided with condensing apparatus, and must, therefore, ordinarily carry a larger water supply.

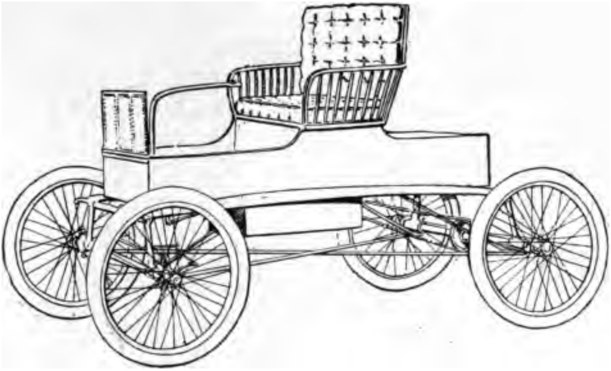


Fig. 49. Steam Runabout.

The question of weights of steam vehicles is usually not one of necessity, but is decided mostly by the designer's individual opinion in regard to the requirements for strength in running gear and engine.

In the Crouch steam vehicle the boiler is a nest of nearly upright helix-bent tubes, and a similar style is used in Marsh or Atlantic automobiles. In these boilers (Fig. 50), in which the tubes are water tubes, the steam generation is not quite so rapid as in the upright fire-tube boiler, but the form of the tube permits expansion from heat without the danger of rupture of joints, the curved tubes being flexible under lengthwise pressure.

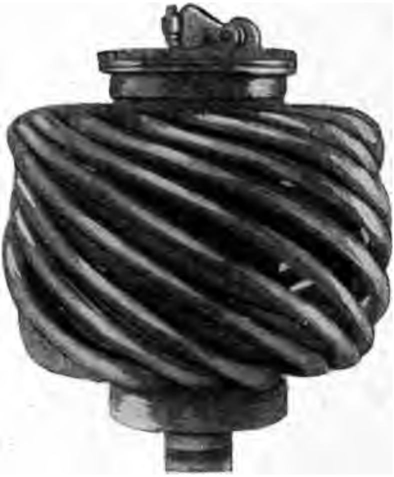


Fig. 50. Boiler in Marsh Wagon.

The engine in the Marsh vehicle is a pair of compound cylinders, while the other vehicles mentioned have only single-expansion engines.

The regulation of the fuel supply, by which the generation of steam is controlled, is one of the most important features in steam vehicle construction, as it must be perfectly automatic for the sake of the safety of unskilled operators, and the convenience of all. In the Stanley pattern the oil flowing from the tank is heated and vaporized as it passes vertically through the boiler, then escapes through capillary orifices and ignites as it comes into contact with air flowing through small air-flues. But when the boiler is first started, some auxiliary means are necessary to volatilize the oil. The means consist of an auxiliary heating tube which connects the burner with the oil-feed tube.

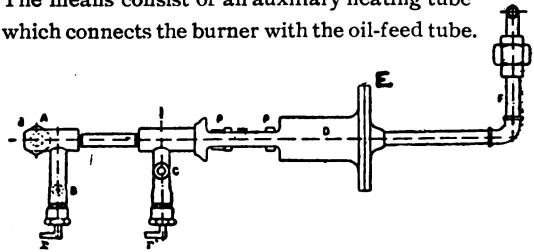


Fig. 51. Diaphragm Control of Fuel Supply.

Fig. 51 shows the method for regulating the flow. The oil-feed regulator is essentially composed of a metallic diaphragm held between the two members E. The right side of the diaphragm is subjected to the boiler pressure; and the left side is connected with a needle valve controlling the flow of oil, the stem of the valve being encased in the body D of the regulator. The oil flows through the tube A to the burner B, first passing through the opening commanded by the valve. The auxiliary heating tube referred to above is mounted at C. The tube F connects the diaphragm with the boiler, so that the steam pressure can act upon the diaphragm. When the pressure becomes excessive the needle valve partially closes the feed opening and reduces the quantity of oil supplied to the burner. When the maximum pressure is reached the opening is almost closed.

The number of manufacturers of steam vehicles has multiplied during the past year, and it is not possible in this book to make any but the briefest mention of the little peculiarities of each.

A few heavy steam omnibuses have been built along the same lines of engine and boiler design as the pleasure carriages, and there are apparently no good reasons why they may not be operated successfully. The same holds true of heavy freight wagons. But in both these branches of the automobile industry very little has yet been done in United States, while English manufacturers have built steam freight vans in considerable number, with a view to short-haul freighting in competition with railroads in densely populated districts, and France has taken very kindly to steam omnibuses, patronizing, in the vicinity of Paris, four different systems of such: the Dion-Bouton, the Scotte, the Weidknecht and the Serpollet. Several lines of these steam omnibuses have, however, ceased to be operated, on account of objections from the road surveyors, who contend that the traffic is injurious to the roads by reason of the great weight of the vehicles, combined with their speed.

The construction of all these heavy steam vehicles is interesting, but is not likely to be transplanted to United States, and may here be left unmentioned. The Serpollet system is the lightest, and the one which differs most from the ordinary steam practice. It is employed also for light pleasure vehicles, and resembles the American type in the exclusive use of petroleum or gasoline for fuel. But it also resembles the internal combustion engine, inasmuch as the power is produced intermittently, superheated steam being generated by the introduction of water in small quantities from the tank to a "flash-boiler," which is a small, thick-walled compartment that is kept heated to such a temperature that it immediately flashes the water into steam when it is injected. Attempts have been made to introduce the Serpollet system in this country. It includes condensing apparatus, and is generally looked upon as giving satisfactory results for light as well as for heavy work.

Part III

Electric Storage Battery Vehicles

CHAPTER XI

STORAGE BATTERIES AS A POWER SOURCE

Although the invention of the electric storage battery, or accumulator, dates back nearly sixty years, it is scarcely nine years since electrical energy in this form was first used for the propulsion of vehicles over common roads. Practically all electric automobiles in use at the present time derive their power from one or more storage batteries; that is, series of chemical elements which may be charged with a store of potential electrical energy by the chemical action caused by an electric current; and are capable of giving off a similar current by a reversal of the first chemical action, the reversal taking effect, gradually, when the elements are connected in a certain manner by electric conductors.

As the charging current is produced from a dynamo, usually driven by a steam engine, and is then converted into chemical action, from whose undoing a new current is produced, to be in its turn converted into mechanical motion by means of an electric motor, which forms part of the vehicle, it is seen that the power derived from a storage battery may be traced back to the heat units contained in the fuel burned under a steam engine boiler. By each of the conversions of power from one form to another there is a considerable loss, so that the power finally obtained from the electric motor represents only a small percentage of that which has been used to produce it.

In contradistinction to hydro-carbon motors and steam engines, which are termed "primary" motors, the storage battery is a "secondary" motive power, the mechanical motion derived from it being the second mechanical motion in the process of generating power.

In the same sense compressed air and liquid air are termed secondary power sources.

From the theoretical standpoint storage battery power is, for the reasons given, extremely wasteful and expensive, but it possesses other characteristics which render it very desirable and useful for certain kinds of vehicle work, as may be judged from the mere fact that there are more electric vehicles in use, in this country, than automobiles of all other types combined.

None of the reasons which may be assigned for the present popularity of electric vehicles in the

United States is in itself sufficient to explain the fact, but all together they furnish all the explanation that could be desired. These reasons may be summarized as follows:

1. Power in the form of a storage battery is divested of all the disagreeable accompaniments of combustion—handling of gasoline, heat, smoke, noise, odor—which it is difficult to avoid in the primary generation of power. The employment of a secondary power source relegates these features to the power station where the charging current is produced, and removes them from the hundreds or thousands of vehicles whose batteries may all be charged from that station.

2. The skill required for operating and caretaking of electric vehicles in a fairly satisfactory manner may be acquired without the least understanding of their construction, being reducible to few and simple rules.

3. The electric motor gives rotary motion; which may be used for vehicle work without the interposition of complicated transmission gear or fly-wheel.

4. The batteries and motors may be produced rapidly at very low cost and sold at a very high price; partly on account of patent protection; thus stimulating manufacture, consolidation of capital and energetic organization of sales.

5. The very large number of electric light plants

in United States insures facilities for recharging batteries even in small towns.

6. Excessive drains upon the power of the battery have no immediately visible effects, so that the vehicle appears capable of a wider range of work than that for which it is really suited.

7. When new and in good order the vehicle works perfectly and with hardly any of the minor annoyances that with primary motors may be caused by the operator's negligence or ignorance; this enables exhibitors and salesmen of electric vehicles to make an excellent "showing."

8. The heaviest expense in maintenance, namely, renewal of worn-out batteries, may at time of sale be truthfully represented as one belonging to a somewhat remote future (about two years), under the proviso that the vehicle shall be always operated in perfect accordance with certain rules.

9. The mechanism does not invite tinkering by unskilled persons in cases when repairs are needed.

The disadvantages of electric vehicles are principally:

1. Uncertainty of the mileage for which the battery will furnish power on one charge; the mileage depending heavily upon the nature of road, load and wind.

2. Rapid deterioration of battery if operated when nearly exhausted.

3. High cost of power-current, compared to power from primary motors.

4. Great weight of power source and structure required to support it; resulting in corresponding reduction of pay-load (''pay-load'' being understood as that load for the transportation of which the vehicle is operated).

5. Liability of battery to injury from travel over rough ground; the chief material in the battery being lead.

6. Difficulties in producing tires that will endure the weight of the heavier styles of electric vehicles.

These disadvantages limit the field of work for which electric vehicles are fit, but do not detract seriously from their usefulness, convenience and elegance so long as they are used within their sphere of work. This sphere of work comprises: Transportation of small loads (passengers or goods) over routes of known distance and traction resistance, and within a radius of about ten miles from charging stations.

Comparing the energy of an electric current with mechanical forms of power, the terms used are volts and amperes, voltage representing the tension of the current and corresponding to speed, and amperage representing its volume and corresponding to mass. As speed multiplied by mass, or weight, gives power, or momentum, so volts multiplied by amperes of a current give the number of electrical work units in the current. This unit is termed a watt; and 746 watts are considered equal to one horse-power.

All electrical apparatus must be suited by its dimensions and material for carrying or transmitting currents of the voltage and amperage with which the apparatus is intended to be worked.

As it is manifestly impossible in this book to initiate those readers who may be unacquainted with the nature of a storage battery and the data of electrical science and engineering, in the manifold aspects of a subject so large and difficult, nothing more shall here be said to explain electrical terms; but the descriptions given in the following chapters will dwell principally upon those points which may be understood without such technical knowledge.

It should be noted, however, that a real understanding of relative merits of construction in electric carriages cannot be gained without previous thorough theoretical and practical study of electrical science.

CHAPTER XII

CONSTRUCTION FEATURES OF TYPICAL ELECTRIC VEHICLES

The first valuable improvements in storage batteries for practical use were due to the great desirability of power economy in manufacturing plants where the demands made upon the power would vary over a large range at the different hours of day and night. To run primary motors economically they should be kept up close to their full capacity until all the power required for the day has been developed, and then shut down. To do this where the power cannot be used as fast as it is being produced, requires some sort of power reservoir which may be tapped after the primary motor has been stopped. The electric storage battery answered this requirement, and is now being utilized for this purpose more extensively every year.

The next practical application of large storage batteries was as motive power for street railways and other short railway lines, but for this they proved much less economical than the trolley system, and have in most places been abandoned in favor of the latter despite the great advantage of dispensing with all need of charged wires in the streets.

It was through these uses, however, that the storage battery was perfected so as to become available for vehicles intended to travel over common roads.

The first carriage in which it was successfully used in United States was built by Morris & Salom, of Philadelphia, in 1895, and took part in the automobile contest arranged by the Chicago Herald in the late fall (Thanksgiving Day) of that year. This vehicle was called an "electrobat" (a term which has since gone out of use), and is illustrated in Fig. 52. Forty-eight small battery elements confined in hard rubber jars,

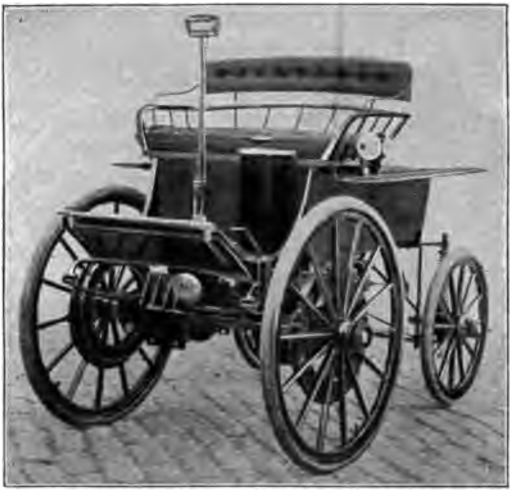


Fig. 52. Morris & Salom's "Electrobat."

4x4x5 in size, and of 50 ampere hour capacity, were grouped in four trays, each containing 12 cells. As there were 24 volts in each tray, the total obtained was 96 working volts. This electrical energy of 96 volts multiplied by a current of 5 amperes, would give, through the motor, power equal to 96×5=480 watts, a little more than one-half horse-power; this would drive the carriage at about 6 miles an hour over a very smooth and level road for ten hours, or a total of 60 miles. At an output of 10 amperes a power would be exerted of 96×10=960 watts, or about 1¼ horse-power; this energy would drive the carriage, the conditions being the same, 12 miles an hour for something over four hours or 48 miles on one charge. The state of the roads on the day of the Herald race was so terribly bad that no estimate of the energy needed to propel the carriage at any kind of regular speed could be made beforehand, but the record of electrical energy exerted by the little batteries in this carriage was a surprise even to experienced storage-battery constructors. The following extracts from the expert report of this trip through the unbroken snow are of interest:

The weight of carriage, 981 lbs.
The weight of batteries, 669 lbs.
Number of cells, 48.
Capacity of cells in ampere hours, 50.
At a discharge of 20 amperes, 40 ampere hours

Weight of vehicle and occupants, 2,000 lbs.

Output of current necessary to start carriage in the snow, 50 amperes.

Current drawn from two series of 24 cells, 48 volts.

Power from each series, 25 amperes; 2 series, 50 amperes; 48×50=2,400 watts=3 horse-power and 162 watts.

This pull, of course, lasted for a few moments only. Moving through the snow at an estimated speed of 3 miles an hour the discharge was 25 amperes and 48 volts, batteries still in parallel; 48×25=1,200 watts=1½ horse-power.

The power consumption by an estimated speed of 7 miles on the snow of Michigan Avenue, was as follows:

Snow broken up, not packed, 25 amperes, 96 volts, batteries in series; 25×96=2,400 watts, same as first pull; 3 horse-power, 162 watts.

Short space of smooth road on avenue, speed increased to 10 miles, current 16 amperes, 96 volts; or 1,536 watts=2 horse-power and 44 watts.

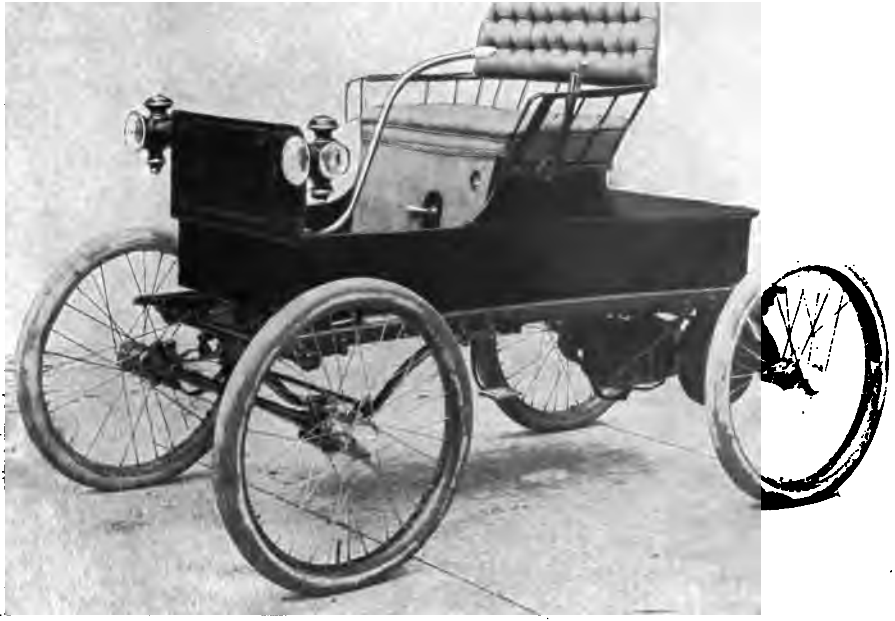
Going over Rush Street bridge, where the incline was steep and ice and snow rough, Morris & Salom vehicle passed without trouble, although the demand on the batteries was tremendous, reaching 40 amperes and 90 volts, or an exertion of energy equal to 3,600 watts, or 4¾ horse-power.

The problem of the utilization of the power, once stored in the battery, has proved as difficult as the construction of the battery itself, the great difficulty at issue being that the momentarily excessive demands for current in starting a vehicle must be provided for both in battery and motors, and especially in controller arrangement. Formerly very large batteries were used to obtain this result, all of which were not allowed to be in use in starting, for, if they were thus exerted, a resistance was introduced consuming, or rather wasting, a large percentage of energy, which did not do the work actually required. The prime factor in the arrangement of a controller for varying speed and for starting is to always have all the batteries in equal service. In other words, they must charge and discharge alike. This is done by means of a wireless controller or grouper, that enables all batteries to be worked alike under all conditions.

The Morris & Salom "electrobat" of 1895 signified the beginning of a large industrial movement for the manufacture of electric vehicles commonly known as the electric vehicle "trust," clustering around the manufacturing company in Philadelphia that furnishes the batteries. These batteries are known as Chloride batteries, and certain points in their manufacture are controlled under patents which have been sustained in court. Several other kinds of batteries are made, however, the most important variety being known as the Planté or Electro-chemical battery, which is also extensively used, being specified by two manufacturing companies whose output of electric vehicles ranks next to that of the aggregation of manufacturing and transportation companies which comprise the "trust."

Figs. 53, 54 and 55 illustrate three styles of vehicles made by one of these companies.

The road-wagon shown in Fig. 53 has a single motor, suspended from the side-bars and in front of the driving axle, the latter being quilled so as to give a rigid construction. The rawhide motor pinion engages a differential gear on the driving axle. The batteries consist of forty cells, giving a maximum travel of twenty miles on a single charge. The cells are housed in the body of the vehicle, which is suspended on a double set of springs. The controller of this vehicle is on the left side, where the operator sits, and the steering lever is within easy reach of the right hand. All functions of the vehicle, except steering, are subject to the operation of the controller lever. One notch forward gives the first speed of three and one-half mile; two notches, the second, of seven miles; and three notches, the third, fourteen miles per hour. By bringing the lever to a vertical position the current is cut off, and a band brake on the motor shaft is applied. The reversing switch is placed under the operator's seat; the reverse speeds are the same as forward speeds.



By removing a key from the reversing switch, the vehicle is practically locked; it cannot move by its own power until the key is replaced.

This road-wagon has an extremely long wheel base, in order to make it an easy-riding vehicle.

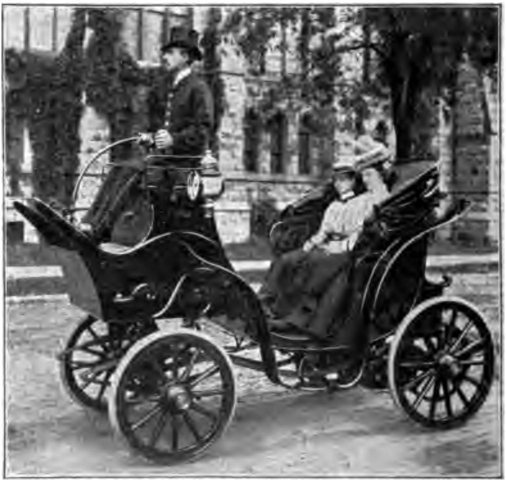


Fig. 54. Victoria with Electric Motor.

It is equipped with either wooden wheels and solid rubber tires, or suspension wheels and pneumatic tires.

The weight of this automobile is 900 pounds. It may be equipped with a top and with a recording voltmeter and ammeter. The batteries can be charged in three hours' time.

Figs. 54 and 55 show a victoria and a brougham. They are each equipped with two motors; the rear wheels being driven independently of one another, each by one motor, so as to dispense with the need of a differential gear on the rear axle. As can be seen in the illustrations, the batteries are housed half in the boot and half under the body-seat. This permits a design resembling ordinary carriage construction. The control is the same as is used in all vehicles with double motor equipments

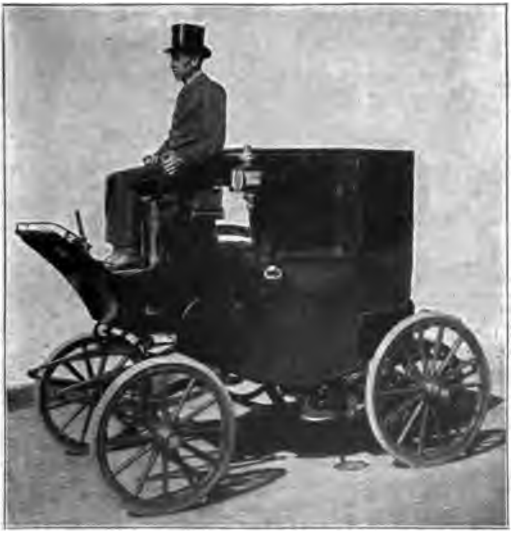


Fig. 55. Brougham.

of this make. The vehicles may be designed so as to be operated from the rear seat as well as from the front perch, and may be equipped with an electrical foot-warmer and a recording volt- and am-meter.

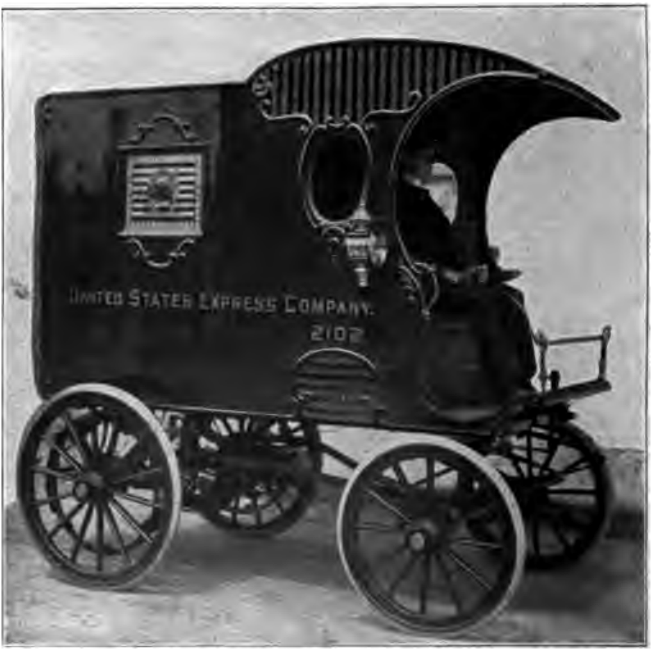


Fig. 56. Electric Merchandise-Delivery Vehicle.

The automobile bearing the name of the United

States Express Company (Fig. 56), has the double motor equipments. The total weight is 2,800 pounds, the load capacity 1,200 pounds; and it has three speeds, two and a half, five and ten miles per hour.

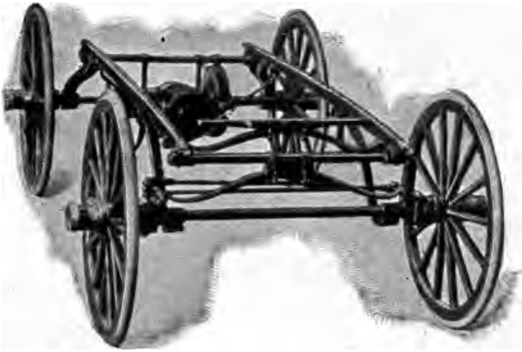


Fig. 57. Single Motor Equipment.

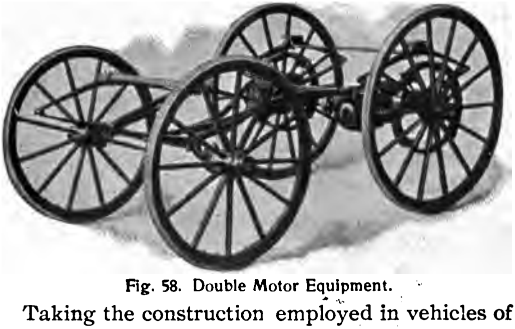


Fig. 58. Double Motor Equipment.

Taking the construction employed in vehicles of this manufacture as an example of electric vehicle construction in general, some of the details of the same are described in the following, but the reader

DATA OF SINGLE MOTOR EQUIPMENT FOR VEHICLES.

FOR FOUR STYLES OF VEHICLES.

	No. 5.	No. 6.	No. 7.	No. 8.
Weight of vehicle only	240 lbs.	425 lbs.	650 lbs.	1,950 lbs.
Weight of batteries	480 "	600 "	800 "	1,000 "
Weight of one motor	90 "	115 "	175 "	250 "
Complete weight of vehicle	810 "	1,140 "	1,625 "	2,250 "
Load capacity	350 "	350 "	700 "	1,100 "
Total load propelled	1,160 "	1,500 "	2,325 "	3,300 "
Normal H. P. of motor	1.16	1.5	2.32	3.34
Maximum H. P. of motor	2.32	3.34	5	7
Speed of motor, revolutions per minute	1,000	1,000	900	850
No. of motor	V 2	V 3	V 4	V 5
No. of battery cells	1,001	1,005	1,007	1,009
Number of battery cells	40	40	40	40
Maximum speed of vehicle, miles per hour	12	12	12	12
Hours time of running	3.5	3.5	3.5	3
Average mileage capacity	36	36	36	30
Diameter of rear wheel	32 in.	36 in.	36 in.	36 in.
Diameter of front wheel	28 "	32 "	32 "	32 "
Diameter of differential gear	14 "	15½ "	19½ "	19½ "
Diameter of motor gear	2 "	2 "	2½ "	2½ "
Diameter of hard rubber tire	1 "	1¼ "	1½ "	1⅝ "
Diameter of pneumatic tire	2 "	2½ "	3 "	3½ "
Size of axle, round	1¼ "	1½ "	1⅝ "	1⅞ "
Width of batteries in vehicle	27 "	27 "	27 "	27 "
Length of batteries in vehicle	29 "	29 "	40 "	52 "
Height of batteries in vehicle	9 "	11 "	11 "	11 "

DATA OF DOUBLE MOTOR EQUIPMENT FOR VEHICLES.

FOR FOUR STYLES OF VEHICLES.

	No. 1.	No. 2.	No, 3.	No. 4.
Weight of vehicle only.	410 lbs.	650 lbs.	950 lbs.	1,400 lbs.
Weight of batteries	600 "	800 "	1,000 "	1,600 "
Weight of two motors	140 "	180 "	230 "	350 "
Complete weight of vehicle	1,140 "	1,630 "	2,180 "	3,350 "
Load capacity	350 "	700 "	1,100 "	1,600 "
Total load propelled	1,500 "	2,330 "	3,280 "	4,950 "
Normal H. P. of each motor	.75	1.16	1.67	2.5
Maximum H. P. of motor	1.5	2.32	3.34	5
Speed of motor, revolutions per minute	1,000	1,000	850	775
No. of motor	V 1	V 2	V 3	V 4
No. of battery cells	1,005	1,007	1,009	1,013
Number of battery cells	40	40	40	40
Maximnm speed of vehicles, miles per hour	12	12	12	12
Hours time of running	3.5	3.5	3	3
Average mileage capacity	36	36	30	30
Diameter of rear wheel	36 in.	36 in.	38 in.	42 in.
Diameter of front wheel	32 "	32 "	34 "	36 "
Diameter of wheel gear	19½ "	19⅓ "	20¾ "	20¾ "
Diameter of motor gear	2½ "	3⅓ "	3 "	3 "
Diameter of hard rubber tire	1¼ "	1½ "	1¾ "	2 "
Diameter of pneumatic tire	2½ "	3 "	3⅓ "	4 "
Size of axle, round	1¼ "	1⅓ "	1¾ "	2 "
Width of batteries in vehicle	27 "	27 "	27 "	27 "
Length of batteries in vehicles	29 "	40 "	52 "	74 "
Height of batteries in vehicle	11 "	11 "	11 "	11 "

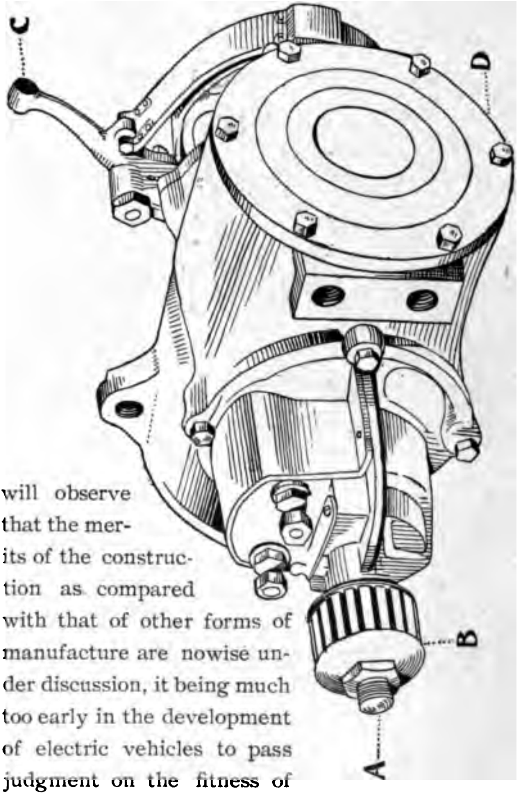


Fig. 59. Motor for Electric Vehicle. A, motor-shaft; B, commutator; C, band-brake, D, motor-casing.

will observe that the merits of the construction as compared with that of other forms of manufacture are nowise under discussion, it being much too early in the development of electric vehicles to pass judgment on the fitness of the various patterns of vehicles; besides being beyond the scope of this book.

It is one of the open questions whether it is preferable to operate electric vehicles with one or two motors. The two-motor arrangement allows the motors to adjust themselves automatically to any difference in power required in each wheel for turning the vehicle around.

Accidents have occurred with experimental wagons supplied with two motors from one of the wheels "seizing" on the axle while the other continued revolving and turned the vehicle into the curb of the street, but the same might occur, with one motor, if the differential gear should become disabled. In either case it would be due to defective workmanship rather than bad construction.

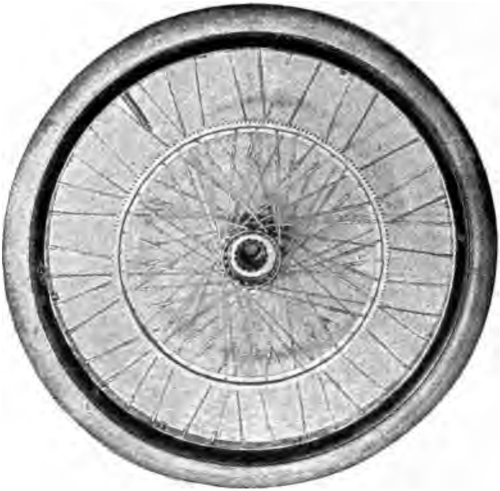


Fig. 60. Driving-Wheel with External Gear.

One of the strongest reasons for using two motors is the desirability of having an undivided rear axle to support the great weight of the batteries. To obtain the same strength with an axle divided by a differential gear involves a more complicated design, though it must be noted that one manufacturer obviates this difficulty by placing the differential gear within the hub of one of the wheels.

In the two accompanying tables (pp. 182 and 183) are shown the variations in weight, dimensions, etc., that are found necessary in the equipments of various styles of vehicles of the same manufacture, accordingly as one or two motors are employed; the weights indicating that the double motor is deemed preferable, in this case, for the heavy styles of vehicles in which the weight supported on the driving axle is considerable.

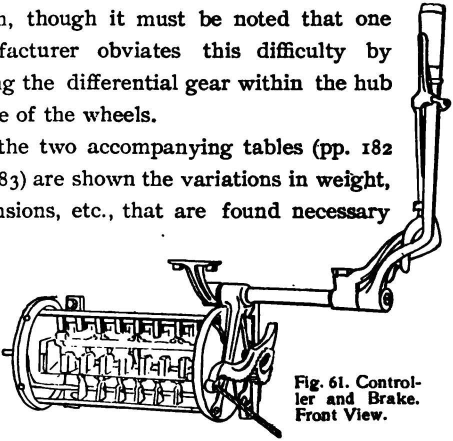


Fig. 61. Controller and Brake. Front View.

The difference in running gear of the two forms of equipment is shown in Figs. 57 and 58.

In the vehicles with single motor equipment there is supplied a special reduction gearing, between the motor pinion and the differential gear, to be used when necessary for ascending very steep grades. The large gears are made from metal, the small ones from rawhide, thereby securing more nearly noiseless operation and less jarring of the motor at starts, stops and other speed changes.

The brake is self-contained in the motor (Fig. 59); no brake of any form is required on the vehicle wheels, proper, by the methods now used. A ten-pound pressure of the hand or foot, according to arrangement, in a movement not exceeding three inches, will stop a vehicle running at full speed in about twice its length, the great speed reduction

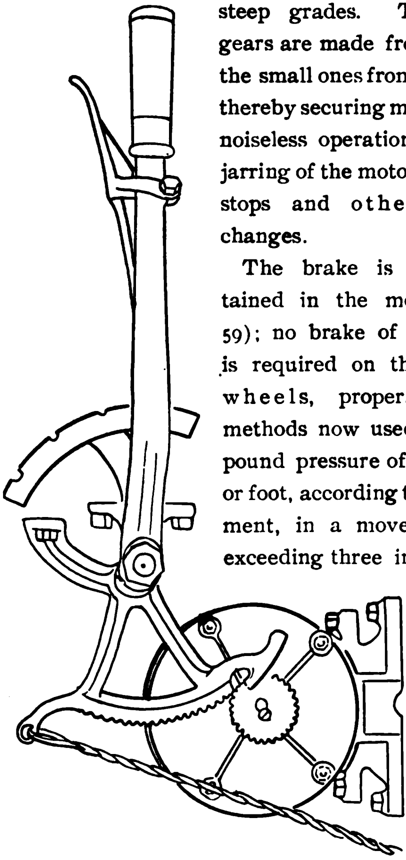


Fig. 62. Controller and Brake.

from the small motor pinion to the large spur gear on the wheels (Fig. 60), or the differential gear, in the case of double motor equipment, assisting in accomplishing this result.

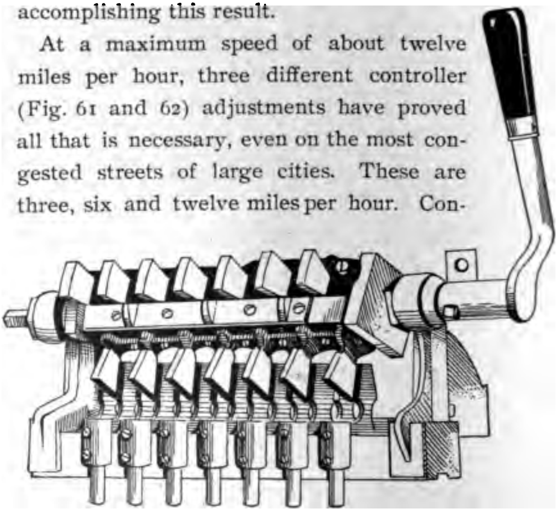


Fig. 63. Reversing Switch.

At a maximum speed of about twelve miles per hour, three different controller (Fig. 61 and 62) adjustments have proved all that is necessary, even on the most congested streets of large cities. These are three, six and twelve miles per hour. Controllers or groupers for as many as five different speeds are made, for vehicles intended for higher speeds.

Fig. 63 illustrates the reversing switch, which has exactly the same mechanical construction as the controller, and is placed immediately under the seat of the operator. With it the motor can be reversed and the vehicle run backward under exactly the same condition as it is run forward. This switch is arranged so as to be either on the right or left hand, according to the driver's choice of seat.

A popular steering device (Fig. 64) is fitted with ball bearings at the top and bottom of the head, and the height of handle from floor is standardized to twenty inches; it is left twenty-four inches long, bent in such shape that it may be shortened to fit varying demands. The under-attachment, which connects the handle to the steering rod of the wheels, is made with a universal joint, allowing the handle to oscillate in any direction on the springs of the wagon, without interfering with its operation or alignment.

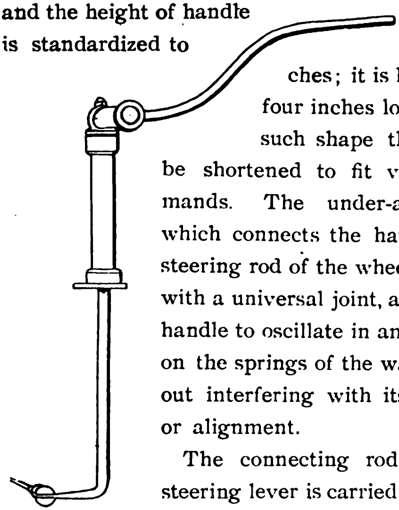


Fig. 64.
Steering Head
and Lever.

The connecting rod from the steering lever is carried both ways to a steering knuckle (Fig. 65), which carries the ball bearing axle as a rock shaft (see chapter on steering).

The reader will find elsewhere a detailed chapter on the care of batteries or accumulators; we limit ourselves by inserting here a type of battery in general use (Fig. 66). It is usually composed of 40 or 44 cells, in 4 trays of 10 or 11 cells each.

These batteries when placed in vehicles are connected with the motor or motors by automatic contacts.

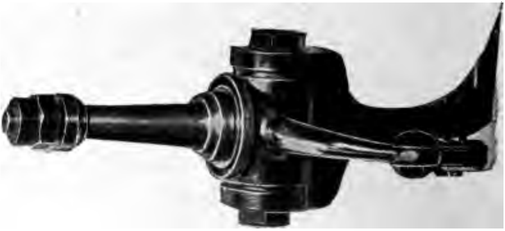


Fig. 65. Steering Knuckle.

Each unit is enclosed in a hard rubber cell, sealed at the top so that it remains always clean and easily handled.

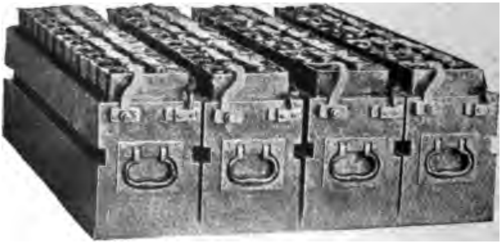


Fig. 66. Accumulators.

CHAPTER XIII

VARIATIONS IN ELECTRIC VEHICLE CONSTRUCTION

In Fig. 67 a "Physician's Phaeton" is shown, which is one of the styles, varying from light buggies to heavy freight trucks, made by the Riker Electric Vehicle Company. The operator in these vehicles steers with his left and controls with his right hand. A single motor is used in all styles. Aside from many minor details in construction by

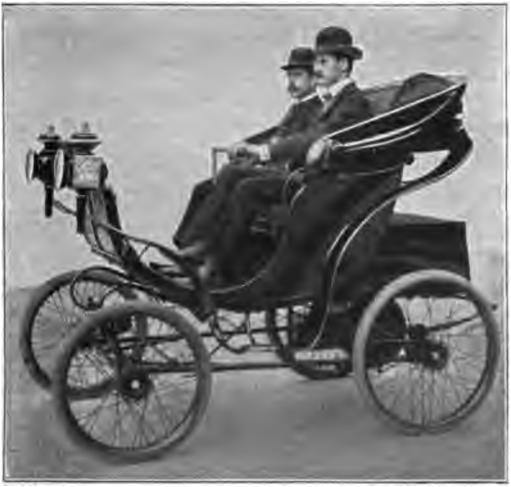


Fig. 67. Electric "Physician's Phaeton."

which the Riker production is known, the differential gear (also called compensating gear, balance gear or turn gear) is worthy of special note.

The ordinary solution of the turn-gear problem consists in dividing the driving shaft in the middle, or rather in providing two shafts, one for each wheel, the shafts being connected at their adjacent ends by a compensating driving connection, a familiar form of which comprises a bevel gear on the end of each shaft and two pinions engaging therewith, carried by a driving wheel rotating on the axis of the shaft as a center. In straightforward motion the pinions act simply as driving keys for the bevel gears; but in case of a turn the pinions turn on their own axes as far as necessary to compensate for the differential speeds of the two wheels. The main objections to this system are weakness, due to dividing the driving shaft at or near the middle thereof, complexity of construction, and inaccessibility for repairs.

The compensating driving gear is illustrated in the accompanying drawings (Fig. 68), of which the larger represents the whole rear axle mechanism of the vehicle as connected with the motor. The shaft B extends the full distance between the hubs of the wheels, and is tubular, inclosing a second shaft, B′, which may be either hollow or solid, and which also extends the full distance between the wheel hubs.

Shaft B is driven directly through pinion d on the motor shaft, and spur gear d′ on shaft B. At one end of the latter is fastened a cup or cage, G, which carries on opposite sides two bevel pinions, g, g′, which rotate on short studs fixed in the cup. The axes of these pinions are in the same line, radial to the shaft B. Engaging these pinions on one side is a bevel gear, G′, which is keyed to the flange of the hub H of the wheel, the said hub being a tubular box, which incloses the compensating mechanism and is supported at the inner end by the ring or closure H′. On the other side of pinions g from gear G′ is another bevel gear, G2, which is keyed to the inner shaft B′, the latter being loose in tubular shaft B. At the other side of the vehicle the wheel hub H2 is keyed to the inner shaft B′, and turns loosely on shaft B. Th

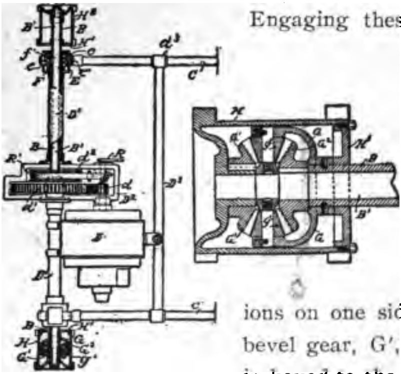


Fig. 68. Riker's Compensating Gear.

the rotation of shaft B carries the pinion g of the compensating mechanism in a circular path around the axis of the shaft, and these pinions engaging with the bevel gear G′, G2, rotate them in the same direction, the pinions not ordinarily rotating, themselves, but acting simply as driving keys. Bevel gear G′, being keyed directly to hub H, imparts motion to that driving wheel, while gear G2, through the intermediary of the inner shaft B′, imparts motion to the hub H2 of the other driving wheel. Obviously, when the vehicle

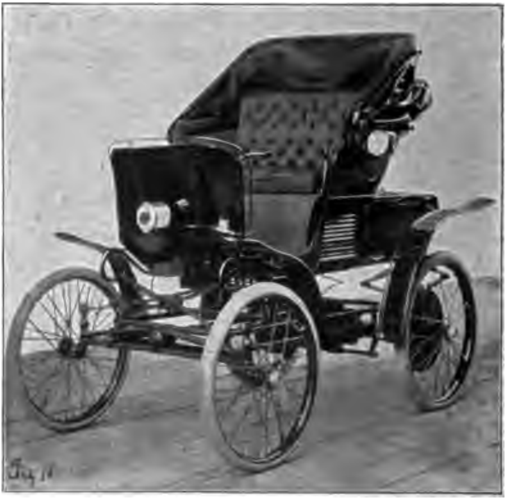


Fig. 69. Waverly Electric Stanhope.

changes the direction of its line of travel, tending to accelerate the motion of one wheel and correspondingly diminish that of the other, the pinions g, g′, by turning on their axes, will permit this differential motion.

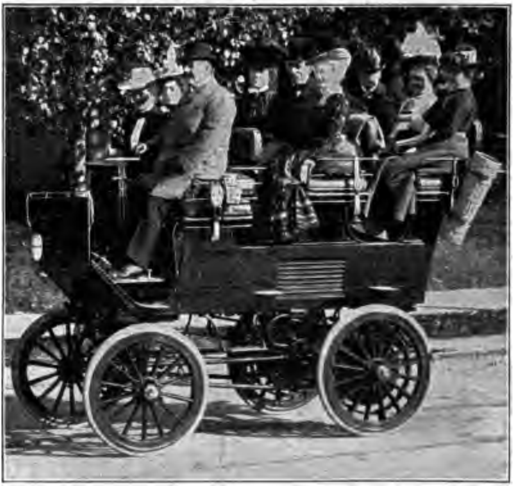


Fig. 70. Electric Tally-Ho.

The principal advantages of this construction are that the driving shaft extends continuously from side to side of the vehicle, affording maximum strength, that the compensating mechanism is readily accessible upon removal of the wheel in whose hub it is inclosed, that it occupies no extra space, and requires no extra housing, and that it requires a relatively small number of parts.

The next illustration, Fig. 69, represents a stanhope made by the Waverly Electric Carriage Company. The most characteristic feature of carriages of this make is the supporting frame, which is built chiefly of steel tubing so trussed as to give more than common strength to the forepart of the carriage, which receives the first shocks on a rough road. The front truss is pivoted to the carriage body in a manner that permits the wheels to adapt their position to any kind of road surface, while also allowing the carriage body free play on its springs. Provisions of this kind are, of course, made also in all other makes of electric vehicles, but seem to have been made the subject of special study in the Waverly carriages. Fig. 70 shows a Waverly Electric Tally-ho, carrying nine passengers. The steering of this heavy vehicle is operated with a horizontal steering wheel, or helm, at the upper end of a standard, the lower end of which carries a worm gear, by which the steering mechanism is actuated. While a worm gear can turn a spur wheel when rotated in mesh with it, the spur wheel cannot react upon the worm; hence its usefulness for steering heavy vehicles, the worm preventing roughness in the road from affecting the position of the wheels and the direction of the carriage, and therefore also preventing the steering lever, or wheel, from "jiggering" in the hand of the operator. On the other hand, the steering by means of a worm is either slow in action or complicated in parts.

In Fig. 71 is shown one of the dozen different styles made by United States Automobile Company, and ranging in weight from 1,000 to 6,000 pounds. These manufacturers, being among the latest in the field, differ on several important points in construction from the majority. The carriage illustrated herewith weighs 2,200 pounds, of which the batteries constitute one-half. Differential gear is dispensed with by means of a special

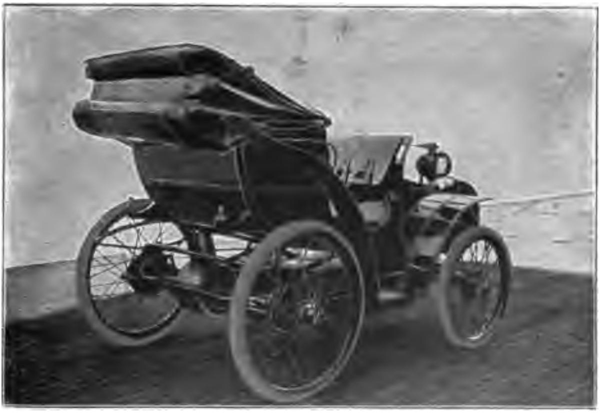


Fig. 71. Electric Phaeton (Battery Mounted Below Carriage Body).

construction of the motor. This motor is mounted to revolve around the middle portion of the rear axle, and both the field and the armature are arranged to revolve. The field of the motor is connected with a reducing gear on the hub of one rear wheel, and the armature with a similar reducing gear on the other rear wheel. The two driving wheels may by this arrangement be worked at different speeds. The battery is suspended from the truck frame on independent springs suited to its weight, and the carriage body may, therefore, be mounted on much easier springs than otherwise would be practicable. The battery being mounted so low makes the carriage very stanch at turns,

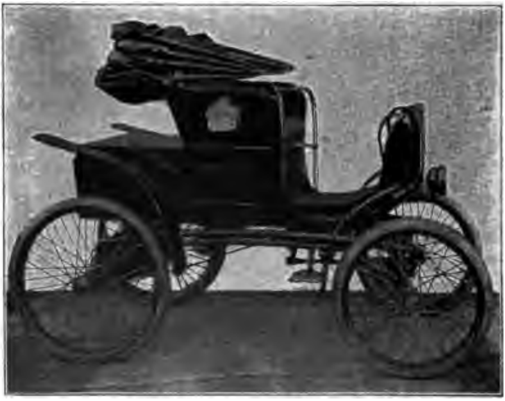


Fig. 72. Motor Phaeton.

and saves wrenching of the wheels and frame. The driver's seat in front—barely visible in the illustration—is low, and arranged for one person only. The steering gear standard is at the side of the seat with the lever extending laterally across so that the steering is accomplished by a pull on the lever for turning to one side—the right—and a push for the other direction, as when a bicycle is steered with one hand. In the lighter styles of vehicles of this make the batteries are placed in the carriage body in the ordinary manner.

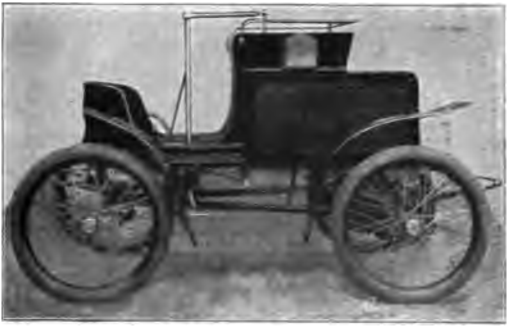


Fig. 73. Runabout.

A series of illustrations, Figs. 72 to 79, represent the forms of manufacture adopted by the Columbia Automobile Company, which is one of the manufacturing branches belonging to the large combination of electric vehicle interests, before referred to.

Some of the details in Columbia construction shall here be mentioned in order to fill out missing links in the general idea of electric carriages, which is all that the lay reader will be able to obtain from any book on the subject.

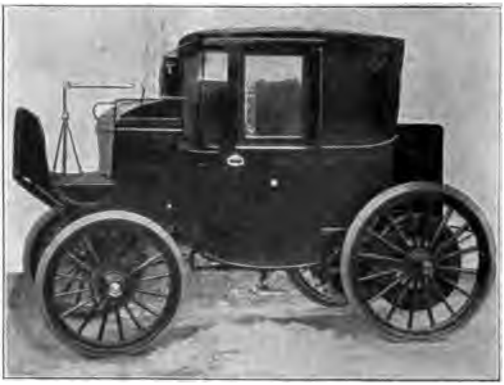


Fig. 74. Brougham.

The motor phaeton (Fig. 72), runabout (Fig. 73), and brougham (Fig. 74) differ largely in design, but very little in electrical construction.

In the phaeton and runabout it is noticed that the frame is made of steel tubing, very little use being made of forgings except for connections of very irregular shape.

An electric gong is operated by a push button placed in the end of the controller handle already mentioned. A meter is conveniently placed in sight of the operator by which he can read how much of the battery power has been used.

The brake adopted is of the band type (Fig. 75). It consists of a compound steel and leather band surrounding the brake pulley balance gear casing, and is arranged to operate equally well whether the brake pulley is rotated in one or the opposite direction. Both ends of the band are, therefore, moved to set the brake in action, which is accomplished through a compound lever arrangement, each end of the brake being fastened to separate levers, which interlock, so that the operation of one, to which one end of the brake is connected, also moves the other lever in the same direction. The operation of the brake by means of the braking foot-lever is by the direct action of a rod, connecting the two parts.

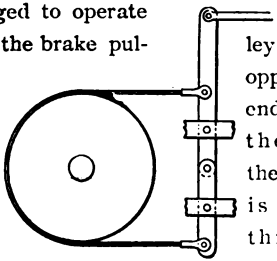
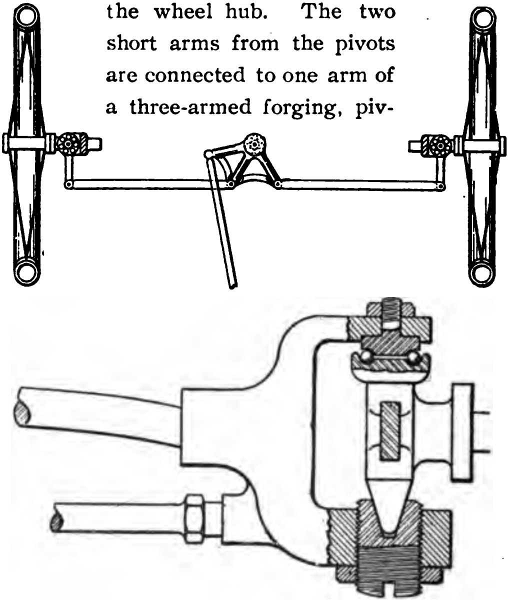


Fig. 75. Band-Brake.

The front steering wheels are pivoted to a horizontal axletree, which is in turn centrally pivoted to the truck frame in order to permit of vertical oscillations of the wheels in passing over obstructions on either side. The method of steering is shown in Figs. 76, 77 and 78. Each of the steering wheels revolves on ball bearings on a short axle pivoted to the axletree-forks, very close to the wheel hub. The two short arms from the pivots are connected to one arm of a three-armed forging, pivoted on ball bearings at the junction of the arms to the center of the axletree. The other arm is connected in turn with the previously mentioned steering handle, which has at its lower end, projecting through the floor of the carriage, a



Figs. 76 & 77. Steering Device.

spiral gear (Fig. 78), meshing into a suitable gear-segment at one end of a pivoted lever, the other end of which is connected by means of a rod to the aim of the triangular steering lever previously mentioned. By the arrangement of this steering device, the wheels, in turning curves, are turned at different angles, in accordance with the requirements explained in chapter on steering.

For the operation of the carriage, three devices are provided, all easily accessible to the operator, who sits on the left-hand side of the carriage. The vertically-placed lever at the side of the seat is used for operating the motor controller. The nearly centrally-placed handle rod, resembling in appearance an ordinary brake handle such as is used on tram cars, is used for steering. At the bottom of the vehicle body, close to the dashboard, is a pivoted foot-operated lever, which is connected with the brake rod to apply the hand brake on the gear casing fitted to the axle. In conjunction with the operation of the controller lever, a peculiar interlocking reversing switch is used, which is operated by means of a foot-push.

The motor is protected by an ironclad casing, entirely surrounding the field windings and armature, and concentrically suspended upon the rear driving axle. The field windings are in section series, connected to the armature. The commutator projects beyond the field magnet frame proper,

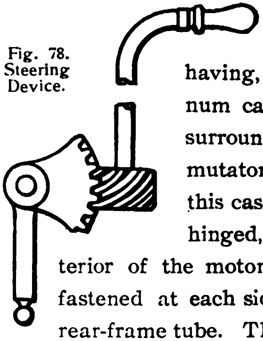


Fig. 78. Steering Device.

the latter being of a rectangular form, and having, at this side, an aluminum casing which completely surrounds the brush and commutator devices. One-half of this casing can be readily unhinged, giving access to the interior of the motor. The field frame is fastened at each side to a hanger from the rear-frame tube. The armature is mounted upon a concentric sleeve surrounding the driving axle, without touching it, being supported by means of ball-bearings in the previously mentioned hangers, also supporting the field frame of the motor. The hollow armature sleeve projects through the bearing at the end opposite the commutator, and a pinion is fastened thereto, which, in turn, meshes with a larger spur-gear on an intermediate spindle, whose motion is then imparted to the balance of the driving gear, to which it is spur-connected.

To operate and control the batteries and motor, a cylindrical controller is used, which is arranged to interlock with a separate foot-operated reversing switch mechanism. The controller cylinder, on which the various contacts are mounted, is turned by means of the operating lever. Connected to the spindle, upon which it is mounted, is a cam which coacts with certain stop-levers connected to the reversing switch. The reversing switch, in its normal position, is set for the forward operation of the carriage, and by means of the controller four speeds can be obtained, three miles an hour being the lowest speed, when the four sets of batteries are connected in multiple. The next step on the controller connects two sets in series, and the two pairs in multiple, which gives six miles an hour. Twelve and one-quarter miles an hour is obtained at the next step, which connects all the batteries in series, and the highest speed of fourteen and three-fourths miles an hour is obtained by throwing the series-motor-field-windings in parallel with each other. If it is desired to reverse the direction in which the vehicle is moving, the operating lever must first be brought back to its normal all-off position before the reversing switch can be operated. After the lever has been brought back a foot-lever at the side of the seat is pressed downward, throwing over the reversing switch to suitably connect the motor and give an opposite relation. After this has been accomplished, the controller lever can be again operated, and another of the previously mentioned speeds can be obtained in the reverse direction. When the controller lever is returned to its normal position the reversing switch automatically returns to the forward con-

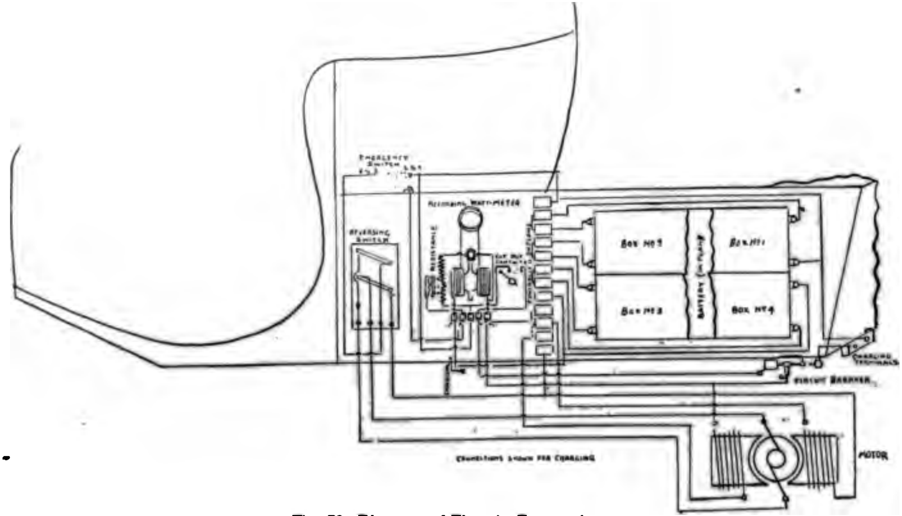


Fig. 79. Diagram of Electric Connections.

tacts. By this arrangement it is impossible to overload the motor by suddenly reversing its connections while going in either direction.

Near the switch is placed a small plug switch for emergency purposes, which can be easily pulled by the operator in case of accident to the motor that would prevent it being stopped by the usual means.

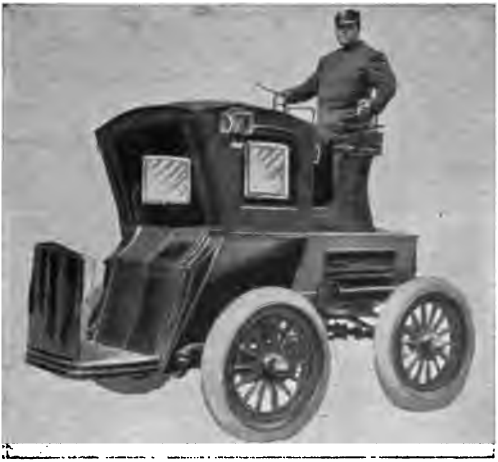


Fig. 80. Electric Hansom Cab.

In Fig. 79 is given a diagram of the general arrangements and connections of the various electrical apparatus used to control and operate these vehicles. All electric connections throughout the carriages which have to be manipulated in any way are made with two different sized plugs and holes, all of the positive being the larger. A mistaken connection is, therefore, impossible.

Fig. 80 represents an electric hansom cab, as made for the Electric Vehicle Company, of New York, with branches in Chicago, Philadelphia, Washington, Boston and other cities. In many of these vehicles the front axle, instead of the rear axle, is driven by the motor, and steering is accomplished by the rear wheels.

CHAPTER XIV

MAINTENANCE AND RECHARGING OF STORAGE BATTERIES

One of the most important points in the successful use of storage batteries, especially when they are employed in automobile propulsion, is their daily care. In the case of stationery batteries, used in lighting plants where every cell is open to inspection, certain fixed rules, laid down by the manufacturer, can be easily carried out, such as keeping the electrolite at the proper specific gravity and always above the top of the plates; but when the cells are small and closely packed together and tightly sealed, it is almost impossible to do this; hence, one having the care of the automobile and its batteries should become so accustomed to the action of the batteries that a test of each cell, with the voltmeter, every night, before charging and after charging, should tell him whether they are in condition for good work.

Every cell properly made has a vent tube in the cover, through which the surplus of hydrogen generated in charging can escape. This vent should be so made that a glance into it by the aid of a small mirror should show the glisten of the liquid just above the top of the plates. If this cannot be done, then a stick of dry wood or a pencil should be inserted into the tube until the top of the plates is felt. If the liquid is of the right height over the plates, moisture will show on the end of the wood; if there is no sign of liquid, then a solution of weak acid and water must be added through a funnel. If the cells show a fair voltage after discharging by use, such as 1 8-10 volt, then a little clear water may be added; but it is generally desirable to have at hand a solution of sulphuric acid and water (5 parts of water to 1 of acid), which is more diluted than the regular electrolite used at first. This solution will show a specific gravity of 1.180, or about 25° Baumé. This is a mixture of about 4 parts water to 1 of acid; the other solution, used for replenishing, is about 20° Baumé, or 1.160. When the batteries are fully charged, and before the charging current is disconnected, the voltage and counter-electromotive forces should show 2 volts and fully $\frac{5}{10}$ of a volt. When disconnected and placed in the vehicle for work, the voltage should be at least 2 volts and $\frac{3}{10}$, with the usual load. Running of the carriage after starting generally causes this voltage to drop to $2\frac{1}{10}$ volts. The majority of the work should show a curve, in which an estimated trip in miles should be made before the voltage is pulled down to $1\frac{8}{10}$ volts. Lower than this it is not well to go, especially if the battery is likely to stand some hours before recharging. The most effective current is 10 per cent of the estimated capacity of the battery. For instance, 10 amperes per hour for 10 hours, for a hundred ampere hour battery; and the most efficient output in discharge is about 12 amperes for eight hours, or twice this amperage four hours.

Once a month the batteries should be taken out of the cells and washed with running water for a few moments; each cell washed out, fresh electrolite at 25° Baumé put in and the battery instantly charged, beginning with a larger ampere current than usual for a short time, and until the battery begins to get warm; then reduce to one-half for the proper number of hours to gain a desired capacity in ampere hours.

If these simple rules are observed, the battery will last much longer and do more work than is generally done by the usual types of batteries. Often a large current is forced into a battery on account of haste, etc. This can be done for a short time, or until the cells become heated above 75 or 80 degrees; then the charging should stop, as the chemical action that goes on after this does little or no good, rather harm. A battery can be so made that it will receive a heavy charging current for an hour, and give an output of about the same amperes as have been put into it; but this endangers the lasting qualities of the plates. If this same battery were charged with a 10 or even

15 per cent current, for more hours, a greater result in work would be obtained. While batteries can be charged in three hours' time, it does not improve them. Six or nine hours will give better results.

When the batteries are being charged in the vehicle, care should be taken to open the body as fully as the doors will permit. This will permit the air to circulate freely and carry off the gases that form during the process of charging.

In the case of storage batteries, neglect allows the forming and the slow but constant growth, upon the exposed spots of the battery plates, of the whitish gray or scaly sulphate of lead, which being chemically different from the sulphating process, that goes on constantly in charging and discharging, is almost non-decomposible except by charging with a heavy current, generating much heat, or by a long, continuous charging with a low current, which even then acts upon the metallic lead under the scaly deposits, and forces it off by expansion. This kind of sulphate is like a fungus growth, and spreads rapidly over the plate if not checked. In a battery constantly in use this is not likely to take place, unless the surface of the electrolite be left for some hours below the top of the plates; hence one of the most important rules and the easiest attended to, is the keeping of the liquid at least one-half inch above the top of the electrodes.

Any one can follow these directions, and while doing it, he can learn by observation many little points where a "stitch in time saves nine." First, keep the liquid always above the top of the plates, with a weak solution of acid if you have it; with rain water or distilled water, if no solution is handy. Second, do not allow the batteries to remain uncharged after fully discharging. Third, look carefully over all the connections between the cells, before and after a trip. Just as the strength of a chain is its weakest link, so the strength of a battery outfit is in its weakest connections. It is by leaving weak spots that resistance is set up, that arcs giving out intense heat are formed, current wasted, and the batteries forced to do more work than needed to propel their load.

It is easy for any one who is caring for an electric vehicle to watch while the battery is charging. By feeling of each connection between cells one can tell, if any unusual heat exists, that something is going wrong. Great heat at any point is sure to cause trouble. It is the sign of a loose or weak connection.

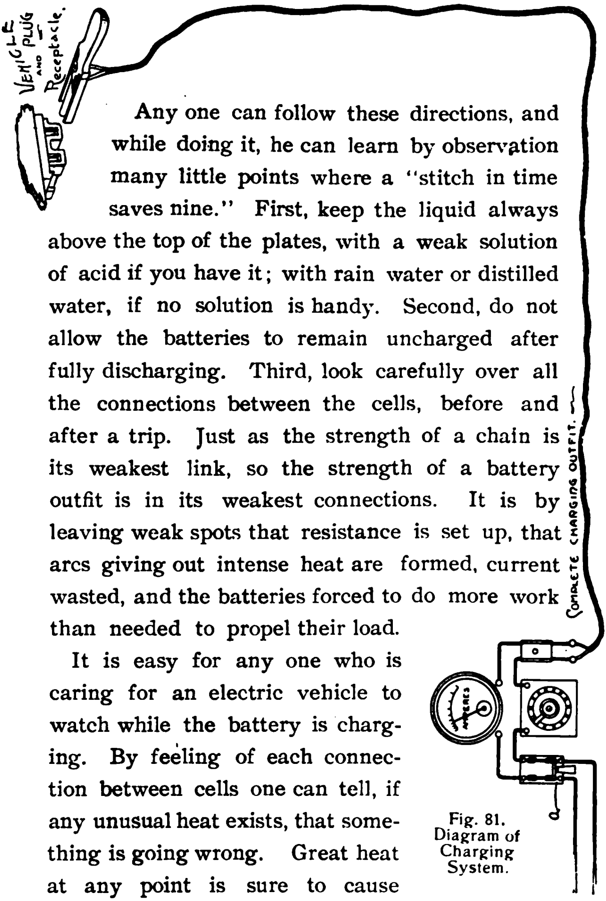


Fig. 81. Diagram of Charging System.

The method and apparatus for connecting the batteries—while in the vehicle—with the generating plant for re-charging are indicated in the diagram, Fig. 81.

Before the plug is placed in the receptacle shown in the diagram, care should be taken that the switch (a) is open. When the plug is inserted in its proper place, it is quite important that the switch be closed quickly, so as to avoid an arc being formed. The operator should also open the body of the vehicle, so as to permit the air to circulate about the cells, for the reason that when the current penetrates the cells it produces gas that escapes from the cells during the process of charging; and unless the air is admitted freely an explosive mixture is liable to be formed. There is no danger whatever if this simple precaution is taken.

Recently a method for charging batteries in forty-five minutes has been brought to a certain degree of practicability for emergenices: but it is not claimed that it is equal in results to the three-hour method, much less to the most approved process which requires an eight-hour application of a weak and constant current.

The quick-charging method consists in using a very strong current for a few minutes by which a coarse and porous deposit of the lead salts is made which gives a largely increased surface upon which the salts may subsequently be precipitated in a more finely comminuted and more available form by gradually decreasing the power of the current for the balance of the forty-five minutes.

In order to assure users of electric vehicles that the cost of maintaining and renewing batteries will not prove excessive, one firm of battery manufacturers undertakes to maintain vehicle batteries at a fixed yearly cost; but this form of insurance is perhaps not as yet very practicable except for vehicle owners in the immediate vicinity of the manufacturers or in large cities where branch factories may be operated, as in other cases the cost of transportation of heavy batteries, as well as time loss are important factors to be considered by the vehicle owners.

CHAPTER XV

NOTABLE PERFORMANCES BY ELECTRIC VEHICLES

While the electric vehicle is recognized as an almost ideal vehicle within its proper sphere of work, those who are practically interested in the manufacture and sale of electric vehicles have not, as a rule, taken pains to inform the public of the exact kind of work for which the storage battery vehicle is adapted; neither have they limited their production to such styles by which the superiority of the type could be demonstrated beyond all doubt or fault-finding. Their greatest efforts have apparently been aimed at proving that the electric vehicle is better suited for prolonged travel on one charge of battery than anybody conversant with the engineering of storage batteries believes. Many vehicles have been constructed especially to show a large traveling radius, and long trips have been undertaken with them in order to have it publicly stated that "electric vehicles can now be constructed so as to travel 100 miles on one charge of the batteries."

Ordinary electric vehicles constructed with a view to durability and comfort continue, however, to be restricted to a traveling radius that seldom reaches thirty miles under average conditions of road surface, road gradients, load and wind.

The exceptional traveling capacity that has been the subject for public comment on several occasions in France and United States has apparently in all instances been due either to such variations in construction as would unfit the vehicle for general usefulness or to the choice of a route presenting hard, smooth and level roads over the entire distance.

In France a distance of over sixty miles was covered on one battery charge, by using a vehicle which was practically all battery, motor and wheels, being totally devoid of all the comforts of ordinary vehicles.

At several trials in United States batteries have been used in which the regard for durability was sacrificed for a high efficiency at one performance.

In all instances it seems that a practically level roadway has been selected, grades being a very important factor to diminish the traveling radius, on account of the great weight of electric vehicles.

From an article in Electric Review we reprint the following, which gives the views of disinterested electrical engineers on the subject:

"The motor car movement has greatly stimulated the efforts of inventors to produce a storage battery of great capacity per unit of weight, and not a few batteries have been put on the market professing to be of much less weight for equal output than the older forms. An examination of these new batteries and of the specifications reveals the fact that the inventors have not succeeded in making any departure from the essentials of the Faure and Planté cells, lead and lead salts alone being successfully used. The plates consist of lead salts held in or upon a lead grit or electrode.

"In stationary batteries there are no objections to constructing the grids substantially enough to perform the two functions of supporting the active materials and collecting the current therefrom, thus producing cells of considerable weight, six or seven watt-hours per pound weight of battery being a fair result in capacity. Such batteries are well understood and are durable and reliable, but for successful traction work batteries of such weight are not suitable.

"Most inventors endeavor to reduce the weight by increasing the proportion of lead salts to the weight of the grid; in heavy batteries we may find the lead grid equal to twice the weight of lead salts used in making up the plates, while in some recent cells we find it claimed that the grid is only half the weight of the salts.

So long as lead is used in batteries, the only invention possible is in the direction of reducing the mass of lead in the cell, sufficient being left simply to collect the current. The supporting of the active materials being no longer trusted to the grid, the inventor then devised supports of ebonite, glass, acid-proof paper and other materials, much lighter than lead, which are applied in two different ways.

"One uses a grid of vertical lead wires threaded through horizontal strips of ebonite, forming shelves, which carry the active materials and support them. Another takes glass rods as a weft interwoven with lead wires, the glass giving stiffness and resilience to the plates. A third employs very light perforated grids, and supports them by plates of light acid-proof paper, also perforated. Others prefer envelopes of celluloid or ebonite to hold the paste on extremely thin grids.

"In all this there is not much invention. Still, if by some means a battery of great capacity and small weight can be produced, it is worthy of a patent.

"It is claimed for some of these cells that fifteen to sixteen watt-hours per pound of battery, at a discharge rate of one ampere per pound of battery, has been obtained. We have failed, however, to find any independent confirmation of a capacity in any battery exceeding ten to eleven watt-hours per pound. We are convinced that all these high capacity light weight cells will require very frequent renewal of plates; the negatives rapidly decline in capacity in continuous work, and the positive grids soon corrode right through, the internal resistance increasing as these changes go on.

"The renewal of cheap plates as soon as the capacity falls below a certain amount should be provided for in all battery traction projects, renewals forming a large part of the cost of battery traction. Plates which were expensive to renew would be no improvement over cheap plates of the same capacity.

"In judging traction batteries it is not, therefore, sufficient to find the capacity per pound weight only. It is necessary to find how long that capacity is maintained in continuous working. Say, a battery starts with a capacity of two watt-hours per pound, how many full charges and discharges will it stand before the capacity falls to ten watt-hours per pound, and what will be the cost of renewal? These questions are rarely answered in descriptions of new cells.

"In connection with road traction by batteries, we find that most vehicles for that purpose carry 80-volt batteries. Why eighty volts? We have never been able to find out the reason for this singular voltage, why not use larger cells and fewer of them?

"The battery is so near the motor that loss in the leads is negligible. As only 100 to 120 volt circuits can be used for charging 80-volt batteries, probably 80 volts was selected in the days when

110 volts was the usual pressure; but nowadays 200 to 250 is becoming so common that batteries to be used on supply from street mains must be raised to 160, 180, or 200 volts pressure, although small cells do not give quite as high a capacity per pound as larger ones.

"On the whole, inventors have not much room for improvements in lead cells. When they have reduced the grid to a minimum, and supported the active materials by something lighter than lead, their efforts are exhausted, and a possible capacity of about fourteen watt-hours per pound is obtained for a time."

In considering the above quotation in relation to the subject of the traveling radius of electric vehicles, it should be remembered that the distance to be traveled under given external condition with a given amount of power depends first of all upon the weight that it is necessary to carry per unit of power, and secondly upon the management of the power; and also that the scientific management of the power (employing the speed which under varying circumstances is the least expensive and gives the highest motor efficiency) is very much handicapped under severe road conditions, inasmuch as the power that may be saved by skill holds a much smaller proportion to the total expenditure than when the traction resistance is small.

Part IV

Other Forms of Motive Power

CHAPTER XVI

COMPRESSED AIR, LIQUID AIR, AND CARBONIC ACID GAS

Extensive experiments have been made looking to the use of compressed air as a motive power for automobiles and street cars, but, although two crosstown street car lines in New York City were for a time operated by this motive power with some degree of success, and one line of night cars in Chicago also made use of it, it has not yet proved feasible to reduce the system to a satisfactory working basis with the very high degrees of compression (said to have reached 4,000 pounds to the square inch) that are desirable from an economical standpoint, and in order to obtain a maximum of power with a minimum of weight.

The idea of utilizing compressed air for power has been very attractive to many by reason of the very economical methods by which air may be compressed on a large scale and stored in steel bottles at a power station, to be thereafter distributed and kept indefinitely until wanted.

One of the difficulties that have attended its use depends upon the exceedingly low temperatures that are developed by its expansion, causing water from the surrounding atmosphere to be precipitated in the form of ice on the engine and its connections. To counteract this trouble and also gain additional power, inventors have generally had recourse to a system of re-heating the partially expanded air in coiled tubing before passing it into the engine (which is similar to a steam engine, but requires much more lubrication). But by so doing the simplicity and ever-readiness of the whole system are to a great extent forfeited.

Several automobiles have been operated with stored air under moderate compression, but, so far as known, none of them has reached the stage of perfection warranting regular manufacture.

Liquefied air as a motive power is purely in the laboratory stage, although attempts have been made to capitalize large companies for the purpose of applying this modern product to propulsion of automobiles. Compared with compressed air, of which it may be considered an extreme species, it has the advantage that it is at rest in the liquid state so long as it is permitted to evaporate in an uncovered vessel, and does not require strong steel bottles to contain it. Nor, indeed, may it be confined in any manner without danger of explosion.

The scarcity of the product, the difficulties in shipping and storing it, its temperature of 320 degrees below zero, and the utter absence of practical results up to date, render a discussion of its possibilities needless in this place. Only in regard to one point may a popular error be corrected: It has been frequently claimed that liquid air contains more latent power (by expansion to the atmospheric state) per pound than other sources of power, but the following table has been calculated from reliable data to show the true comparative value of the four power sources most frequently mentioned as available for automobiles:

Sources of power—	Foot lbs. per lb. of medium.
Good storage battery	15,000
Liquid air, from 2,000 lbs. to atmosphere	139,100
Coal, 14,600 British Heat Units, used in steam plant of 12½ per cent efficiency	1,408,000
Kerosene oil, 20,700 B. H. U., in internal combustion motor plant of 35 per cent efficiency	5,593,000

While this table shows plainly the theoretical superiority of liquid air—when harnessed—over storage battery, it shows, on the other hand, that the internal-combustion motor on the same grounds may deliver, under the most favorable circumstances, forty times as great a power as liquid air per pound, but it should be admitted that no motors so far used for automobile traction have been worked at an efficiency of 35 per cent, or anything approaching this percentage (which is the basis used in the table), although it is said to have been reached in a stationary kerosene motor, and nearly reached in a stationary two-cycle gasoline motor.

After all, fuel economy, which is so important in manufacturing enterprises, plays only a minor part in deciding the relative merits of the various systems of power generation for automobiles.

Carbonic acid gas, which is much more readily compressed and liquefied than atmospheric air, and may be produced under great compression by the action of acid on marble or by other chemical means, has been applied by one experimenter of Jersey City to drive an automobile, but is not usually considered a desirable power source, having proved especially difficult to subjugate in earlier attempts at utilizing it for industrial work.

CHAPTER XVII

COMBINATION MOTORS—GASOLINE AND ELECTRICITY —GASOLINE AND COMPRESSED AIR

An indicator card or diagram describing by curves the velocity of expansion of gases by the velocity of the piston strokes at their various stages, shows invariably a jagged line for internal-combustion motors, even if they are running at their highest efficiency, although the line, of course, is very much more even for a multicylinder motor at high speed than for a one-cylinder motor at a low speed. Under all circumstances there is an indication of the almost instantaneous explosion of the gas, furnishing evidence of a certain waste of power.

The employment of high motor speed and the multi-cylinder type is the means commonly adopted to equalize the power, but it is not sufficient under great variations in load or traction resistance and speed, principally because the high motor speed cannot be maintained without complicated speed-gearing and manipulation of many operating levers.

The remedy has been sought in another direction, namely, by giving the internal-combustion motor a constant quantity of work by employing it for storing power in one form or another when the traction work is light and drawing upon the stored power when it is heavy.

Several makers of electric vehicles are looking forward to a combination of the internal combustion with the storage battery as the best means for obtaining the simple operation of the electric vehicle without its dependence upon power stations for recharging of batteries.

The ideal method should, generally speaking, consist of hitching a dynamo to the gasoline motor and make the dynamo constantly charge a storage battery, from which a slow-speed, shunt-wound electric motor would draw its power for propelling the vehicle in the usual manner. When the load is light and the traction effort small, the dynamo would charge the battery at a more rapid rate than the electric motor consumed the power, and a reserve power would be stored, to be used when the traction effort rose to a point that would overtax the hydro-carbon motor. There is considerable difficulty, however, in maintaining the efficiency of a battery when it is charged at a high rate, and experiments have therefore taken another form, consisting in driving the vehicle direct from the gasoline motor and drawing upon the storage battery only when the load would otherwise diminish the gasoline motor's speed.

The Munson phaeton shown in Fig. 82 is operated by a combination motor of this class, which weighs 2,000 pounds. The combined hydro-carbon and electric motors give seven nominal horse-power, and the vehicle is geared to two, four, eight and sixteen miles per hour, thus giving four speeds. The accumulators are housed in the body of the vehicle. The motors are suspended on the running gear, and are dust and water proof. Fig. 83 shows this arrangement of mounting the hydro carbon motor on the running gear,

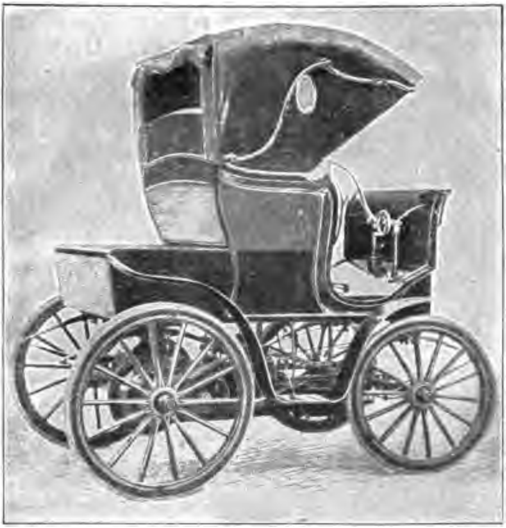


Fig. 82. Munson System Phaeton.

which is common in France, but in this country has been adopted only by two or three manufacturing companies. It facilitates manufacture in different styles of carriage body, which may all be placed on almost identical trucks, and leaves the carriage box free from machinery. On the other hand, it necessitates the use of special gear casing to protect the motor from dust and mud.

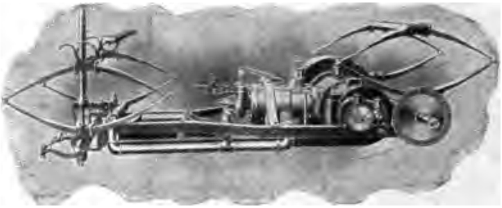


Fig. 83. Motor Mounted on Axle.

A gasoline motor co-operating with a compressed-air engine is another form of combination motor, the gasoline .motor compressing the air, which is then either stored for use when required or used almost at once to equalize the power delivery.

So far as publicly known results are concerned, this class of motors is still in the experimental stage, but vehicles are creditably reported to have been operated successfully by a motor of this kind designed by J. W. Eisenhuth, of New York. The Eisenhuth motor is so constructed that the same piston may be driven from one end by explosive mixture, and from the other by compressed air, so as to obtain a driving effect similar to that of steam power.

Other forms of combined compressed-air and gasoline motors are being tested in two or three localities, and great hopes are entertained of complete success in this branch of automobile construction. As an indication of the value of the combination in regard to power economy it may be mentioned that a gasoline motor with an air-compressing attachment which has been in the market for use in the industries utilizing pneumatic power, is known to operate at the same speed, whether the work of compressing and storing air is added to its other functions or not.

Part V

Miscellaneous Matters

CHAPTER XVIII

THE STEERING OF THE AUTOMOBILE

By "Indus"

Numerous as have been the devices brought forward, in patents and otherwise, for steering mechanically-propelled vehicles, it cannot be said that any of them have proved altogether satisfactory.

It naturally occurs to every constructor commencing to attack the problem of mechanical propulsion on roads, to adopt the four-wheeled type of vehicle as drawn by horses, using the hind wheels as drivers, and retaining the fore carriage or perch to steer by, turning it to one side or the other by the hand of the steersman, either directly or by a lever—which, in this case, would correspond to the pole of a pair-horse carriage, the shafts of a one-horse carriage, or the steering handle of a bath chair—or through the intermediary of cog-wheels, chain-wheels, worm-wheels, or other mechanism.

The constructor soon finds out that to hold the perch firmly in the required direction and rapidly change that direction to satisfy the requirements of the traffic is not so easy as he supposed; and he is surprised to discover that, all his life, he has seen wheeled vehicles without realizing what a great deal the horse has to do in keeping the vehicle straight on its course. If the steering gear is a rapid one, that is, if a small motion of the steersman's hand produces a considerable angle of the helm, so to speak, then his control over the perch, his power to keep it in the desired position, is but small; and if, as is constantly happening, an obstruction such as a stone, or a rut in the road, or a street car rail opposes one wheel of the perch, while the other is unimpeded, the perch is apt to be wrenched round towards the side where the obstruction is, in spite of the efforts of the steersman to prevent it. It is a very pardonable error of judgment, in bringing a four-wheeled vehicle alongside the foot-walk, to let the fore wheel grind the curbstone; with horse vehicles we see this done every day by experienced drivers; seldom do ill results occur beyond wearing out the curb and the wheel tire a little. The weight and strength of the horse, acting at the long leverage of the shafts, keep the perch from swerving.

But let this error be committed by the driver of an automobile with a quick-steering gear, and there is a probability that the perch will be swung around towards the curb, and the vehicle will run onto the sidewalk, to the serious peril of pedestrians and shop windows.

This action is clearly shown in Fig. 84, which represents the wheel plan of a vehicle, the near forewheel of which is meeting the curb at a small angle; the resistance met with, acting at so considerable a distance from the center of motion of the perch, tends to turn the perch round at right angles to the curb, as shown by the dotted lines.

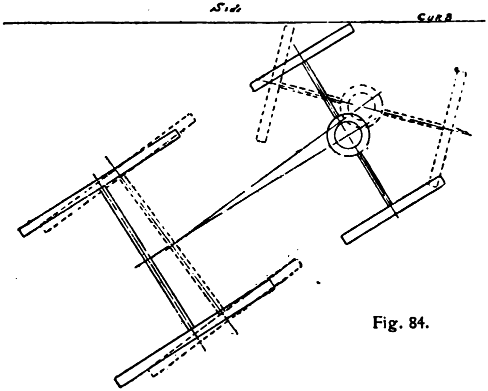


Fig. 84.

If any one doubts that considerable force is necessary to keep the perch straight, let him experiment with one of the small hand-trolleys used in engineering works for moving pieces of machinery from place to place. The fore-perch of the trolley has an iron rod projecting in front like the pole of a carriage, with a cross-bar at the end like that of a garden roller. Let the observer put a considerable weight on the trolley, and drag it at a fair speed, say three miles per hour, across the shop. He will find that unless the floor is smooth he cannot drag it straight, his arms being disagreeably jarred to one side or the other as the fore wheels meet with irregularities; while, if one fore wheel (but not both) meets with a large obstruction he will, if not on his guard, be thrown violently to one side.

Well, after one or two unpleasant experiences with his quick-action perch, our constructor determines to run no more risk in that direction; so he introduces a large-toothed ring on his perch, into which he gears a pinion actuated by a steering wheel, or other contrivance for giving him greater purchase over the perch.

This proves a great success insofar as his hold over the perch is concerned, but, alas! the charm of quick steering is gone. He may, when traveling on the near side of a road, turn down another road at right angles to the right without reducing speed, by describing a wide circle across the road; but he cannot do so to the left without either first going out into the road, or else slacking speed.

So he modifies his gear, and adopts a degree of purchase which he considers a happy medium between the extremes of too slow action on the one hand and too feeble control on the other. Still, he views with disgust a friend of his, on a tricycle-automobile, a form of vehicle he loathes and despises, steering with evident ease and freedom; and he recognizes that a vertical steering axis passing through the plane of the wheel, as in the bicycle or tricycle, is essentially superior to the perch with its long-armed couple.

But, ha! eureka! he has it. Let each fore wheel turn about a vertical axis in its own plane, and let these axes always move through equal angles. Surely that will be a correct motion. What is right for one wheel is surely right for the other, and, therefore, for both. In the case of the perch, do not the fore wheels turn through equal angles about a vertical axis?

There is also a bodily translation, no doubt, but the angular motions are equal. And he knows a simple means of producing this motion; he is familiar with the side-rods of a coupled locomotive, the drag-link by which the two drain-cocks of a steam engine move as one, and many other examples of the jointed parallelogram. So he abandons the perch, and substitutes a pair of steering wheels of the bicycle model, united by two short levers and a drag-link so as to be parallel to each other at every angle of helm. Having made a neat, workmanlike job of this, he sallies forth serenely confident of being right this time.

But a new surprise awaits him. The gear is easy to handle, it is true; the steering handle, which is a prolongation of one of the drag-link levers, is not wrenched from his hand, as in his

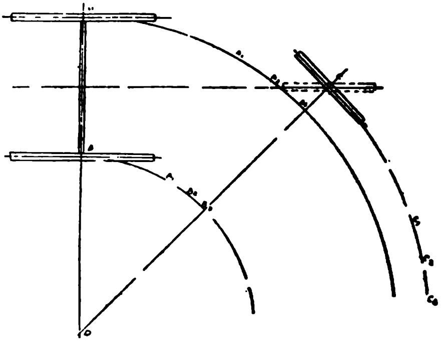


Fig. 85.

first construction, and a large angle of helm can be given in an instant, yet the vehicle is no longer herself. She slows down, and sometimes actually stops, when describing small circles; and never seems to know her own mind in turning sharp corners, sometimes describing a larger and sometimes a smaller circle, with the same angle of helm, especially on wet asphalt or wood. This is truly distressing, because he knows that that detested three-wheeler motocycle of his friend can run any assigned wheel over a mark in the road five times in six tries; nay, more, that the bath-chair, guided by the feeble hand of an aged invalid, preserves one true, definite course at every angle of helm.

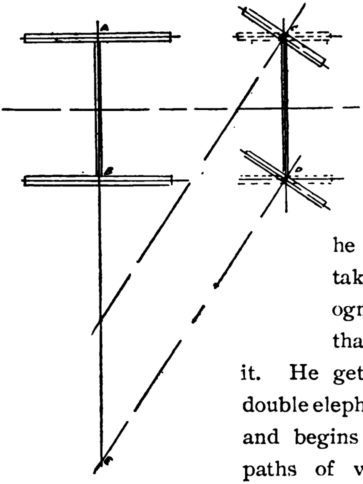


Fig. 86.

Our friend is no fool; if he makes a mistake, he can recognize the fact that he has made it. He gets a sheet of double elephant stretched and begins to plot the paths of vehicles with various positions of the steering wheels.

He is not above beginning with the three-wheeler, not being the sort of person we alluded to in the last paragraph.

He makes a sketch like Fig. 85, to represent the two hind wheels A and B, and the fore or steering wheel C, put over to a certain angle. Before he has well asked himself the question, "What is the point about which the system is revolving?" he has answered it by drawing CD at right angles to the plane of the wheel C, to intersect the line AB produced in D. The point D is clearly the only point about which all three wheels can turn without grinding on the ground, each advancing at any moment in its own plane, although that plane is continually changing. And this is true for every angle of helm; with a greater angle, D approaches B; with a less, D is farther from B.

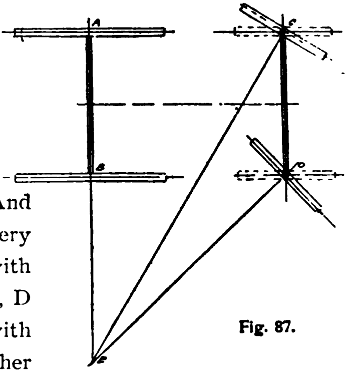
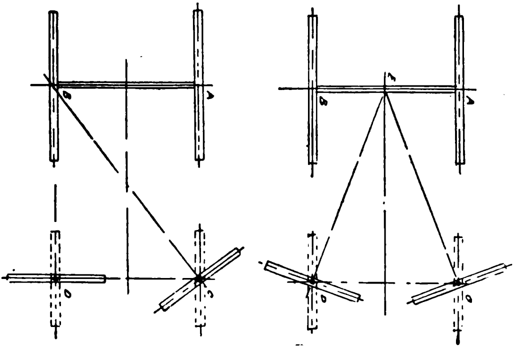


Fig. 87.

He sees his error now; with an intense feeling of chagrin and indignation against himself, he draws the plan of his own four-wheeler, as shown in Fig. 86, and perceives that, if the wheels A, B and C alone existed, the system would turn about the point E; while if A, B and D alone existed, the system would turn about F; and that therefore, when all four, A, B, C and D exist, there is no point which answers the requirements of true running; that is, no point to which the axles of all the wheels, or rather their projections on the horizontal plane, converge.

The reason of the occasional strange behavior of the car whose fore wheels are always parallel is now apparent; the in-weight, or the variations of the co-efficient of friction between the wheels C and D and the road, according as one or the other was on a greasier spot, would bring the center of motion of the system nearer to E or F, as the case might be.

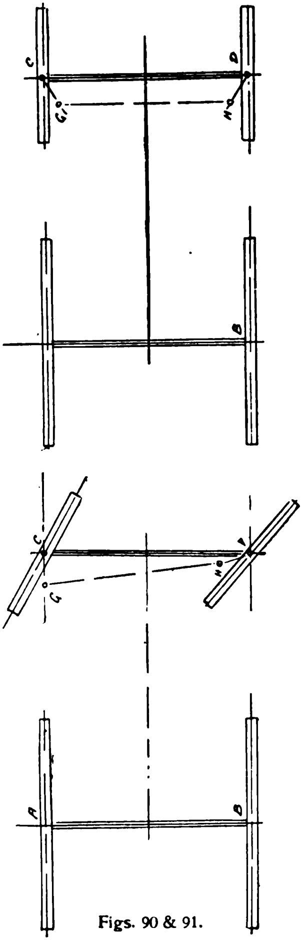


Figs. 88 & 89.

What has to be done to make a satisfactory steering gear for the four-wheeler is now clear, although the means of doing it are not so easily evident. The axles of the four wheels produced, as seen in the plan, must in every position of the gear meet in the line of the axle of the hind wheels, as shown in Fig. 87. The fore wheel on the side towards which the vehicle is turning must clearly move from its normal position through a larger angle than the other for this condition to obtain. Thus, when the wheel D is turned round its vertical axis at right angles to the center line of the vehicle (Fig. 88) the point E coincides with B, that is, the point of contact of the wheel B with the ground becomes the center about which the system turns, and the wheel C has only turned through about half a right angle for its axle to point to the point B.

Turning the wheel D still further, the point E, the center of motion, comes between A and B, as shown in Fig. 89, a position of the wheels which appears at first sight really extraordinary. Yet it gives a true motion of the wheels without grinding on the road; the wheel A may move forward, while B goes backward, C and D revolving each in its own plane, and all without any sideway motion on the road.

In practice the two odd positions of the wheels will never be seen, in rear-driven automobiles, because the wheels before arriving at those positions have assumed angles by which the progress of the vehicle and the operation of the motor are blocked.



Figs. 90 & 91.

An approximation has been attempted by more than one constructor in the following manner: Instead of making a parallel motion as in Fig. 86, in which the drag-link is equal in length to the distance between the vertical pivots of the fore wheels, the drag-link is made considerably shorter, as shown in Fig. 90, where G H is the drag-link, C and D the vertical axes, and C G and D H the short levers which actuate the axes. It is clear that in steering to the right the lever H D, and consequently the wheel D, turn through a greater angle than the lever C G and the wheel C., This gear, however, has a very limited range, for the lever D H and the link H G soon come in the same straight line, as shown in Fig. 91, and this is the extreme angle of helm that can be used; for if D H be turned still further round in the same direction, the link H G will evidently begin to drag the lever C G back, instead of putting it further over. The gear, therefore, cannot be considered a solution of the problem.

CHAPTER XIX

WHEELS, TIRES, DIFFERENTIAL GEARS, BEARINGS

The part played by the driving wheels of an automobile is radically different from that of the wheels of a horse-drawn vehicle; and even the front wheels of a rear-driven automobile are required to endure strains (caused by the power pressing on directly from behind while the front wheels are turned at an angle for steering purposes), which all the wheels of a horse-drawn carriage escape.

The construction of automobile wheels is, therefore, usually more similar to that used for the driving wheels of certain self-propelled agricultural implements than to ordinary carriage wheels. They are of the bicycle wheel or suspension wheel type shown in Fig. 92.

But this style of wheel, while it resists the driving stresses, presents a network of wires which it is difficult to keep clean and neat in appearance, and which is easily weakened by rust. Wire-spoke wheels also want to be made very broad at the hub in order to resist the side stresses that arise at turns or when the wheels are wrenched in a rutty road.

For these and other reasons many automobiles are still fitted with the ordinary wood-spoked or compression wheels (Fig. 93), only strengthened at the hub connections and provided with rubber tires, either hollow and filled with compressed air, or solid. These tires act as cushions, and protect wheels and axles against injury from sudden shocks, particularly those lateral ones that are due to bad roads or speedy turning. As mere carrying wheels, and in regard to strength to resist bumps (shocks which travel from the rim to the hub and in the plane of the wheel), wood-spoked wheels are generally considered equal to wire-spoked — suspension — wheels, but it is understood that unless the construction, material, workmanship and finish is of a very superior order, they are likely to deteriorate under the special stresses to which they are subjected as driving wheels in automobiles, and then suddenly give way at the point where the spokes are secured in hub. The finish of the wooden wheels

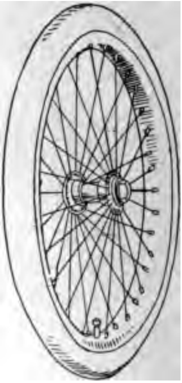


Fig. 92.
Suspension Wheel.

is in this respect of special importance, because it protects the wood against climatic influences which would tend to warp the wood and alternately expand and contract it, thereby loosening the joints.

The special stresses referred to are due to the application of power to the axle or hub of the wheel, rotating the hub forward while the resistance to propulsion — which may be very considerable on hills or at high speeds —tends to prevent the periphery of the wheel from rotating. The same tendency to twist the wheel out of the hub is experienced when the automobile is stopped by brake action, and especially if the brake acts from the motor, as by sudden reversing of the power, or upon the axle or hub of the wheel.

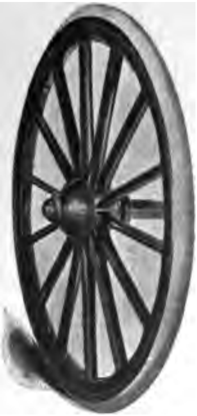


Fig. 93. Compression Wheel.

In suspension wheels all stresses of this nature are resisted by the tensile strength of the wire spokes, the wires being laced tangentially to the hub in exactly the same manner as in all rear wheels of bicycles and driving wheels of agricultural machines.

By this manner of lacing a rotary strain at the hub always follows the length of the wire spoke without any tendency to bend it; and, moreover, the strain is borne not by a single wire but by one-half of the spokes in the wheel, because a rotary strain tends to dislocate all those spokes, simultaneously, which issue from the hub in the opposite direction of the rotary strain; that is, one-half of their number.

In wooden wheels, on the other hand, these rotary strains tend to bend the spokes and compress their inner bezeled ends unevenly against each other; and the ground resistance works with a long leverage at the periphery of the wheel against the short inner ends that are gathered in the hub. The best security against trouble from this cause is found—aside from good workmanship—in enlarging the diameter of the hub flanges between which the inner ends of the spokes are held, and shaping the spokes somewhat like hammer handles, i. e., with a reduced diameter a short distance from the hub, so as to facilitate a slight bending in one place in order to relieve excessive strains at the joints.

In some of the best automobile constructions this hammer handle design will also be found in the axles near the wheels, the object being again to alleviate shocks and prevent the middle portion of the axle, upon which the differential gear is usually mounted, from being sprung.

As an example of the severity reached in the rotary strains referred to, it may be mentioned that in certain heavy automobile freight wagons whose wheels were shod with steel tires, these steel tires buckled under the stress of hauling heavy loads, and that it has been found no easy task to secure rubber tires to the wheel rims with bolts and avoid enlargement of the bolt holes and creeping of the tires on the driving wheels.

This leads to the tire question, which is one that is giving automobile manufacturers much to think about. The choice between solid rubber and pneumatic tires is far from being settled, and something better is persistently sought for by manufacturers.

In all cases the tires of the driving wheels must bear the brunt of the rotary, tangential stresses mentioned with reference to the wheels. When a 2,000-pound motor vehicle is driven up a 10 per cent grade, it is evident that the tangential stress on tire material exceeds 200 pounds at the points of ground contact, or 100 pounds for each tire. In a vehicle going at a speed of three miles per hour the lowest amount of stress—counting on a traction resistance of 80 pounds—equals about 1⅛ horse-power applied to abrade or tear the tire material. With pneumatic tires and a high inflation, the area of ground contact is small, and the likelihood of abrading the tire casing material is thereby increased. With low inflation the stress is largely borne by the fabric, and the means employed for fastening the tire on the wheel rim. The solid rubber tire suffers mostly by abrasion if it is properly fastened.

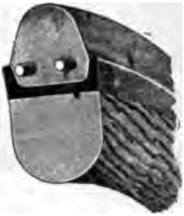


Fig. 94.

Figs. 94, 95 and 96 show common types of solid tires, which are used for ordinary carriages as well as for automobiles.

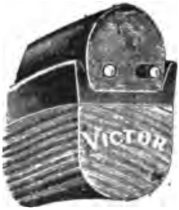


Fig. 95.

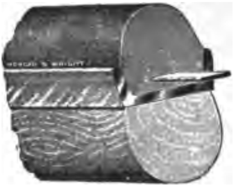


Fig. 96.

Pneumatic tires are mostly of the single-tube variety, only larger and heavier than single-tube bicycle tires. Figs. 97 and 98 show two kinds, both intended to be fastened to a metal wheel rim by screw bolts entering metal lugs that are vulcanized in the tires as shown. The perspective view in Fig. 99 represents the same tire as Fig. 97, and shows a comparatively new departure in the flat tread, which gives this tire a larger area of contact with the ground than may be obtained with the ordinary round tire, when it is highly inflated, and thus protects it somewhat against abrasion of the rubber, there being more material wherewith to resist the abrasive stress.

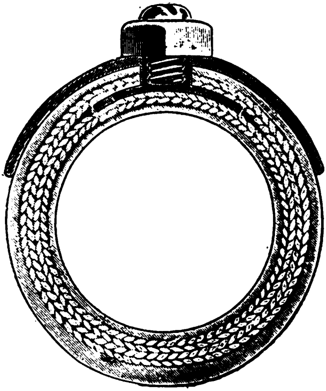


Fig. 97.

A multitude of designs in automobile tires, both solid and pneumatic, have been proposed and tried, but no definite results have been reached proclaiming the superiority of one pattern over

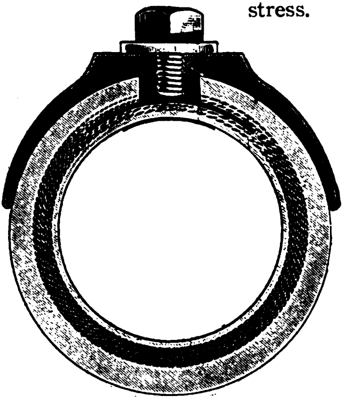


Fig. 98.

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another. Detachable tires and clincher tires are among the number, but in all cases, whether for light or heavy automobiles, the public, as well as manufacturers, must await the verdict of larger experience before the tire question may be considered definitely settled in favor of any one or more patterns. Without further explanation there is presented in Fig. 100 a cross-section of one of the very latest tire patterns, and the means for fastening it to a wooden wheel felly. This tire is designed to be inflated, and to act as an ordinary pneumatic tire under ordinary loads, but under heavy loads or when insufficiently inflated, the two internal buffers in the tire meet as shown in dotted lines, and the tire then acts as a cushion tire.

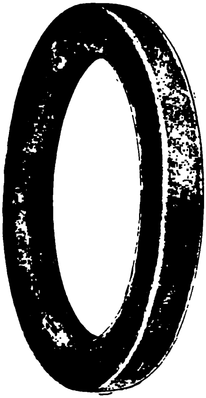


Fig. 99.

The complexity of the arrangement will make it evident to the reader that the questions involved in the tire problem are numerous and knotty.

The keynote to the tire situation is, however, the one important fact that the lighter the automobile and the less speed there is demanded of it the more readily may it be equipped with tires that will prove satisfactory.

The means ordinarily used for inflating automobile tires is a compression pump operated by hand, as for bicycles, but on account of the high

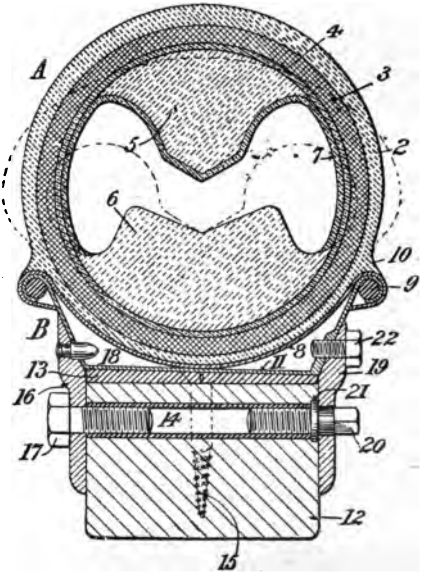


Fig. 100. Pneumatic Cushion Tire and Attaching Device.

pressures wanted in automobile tires—from 60 to 140 pounds—it is preferable to use a large pump geared down and operated by a crank, or to have the pump connected with an engine. Recently carbonic acid gas has been utilized in the same form in which it is used for drawing beer from the barrel, namely, in steel cylinders under an initial pressure of 1,000 pounds per square inch, and there has been placed on the market a cabinet containing a small, compact inflating outfit, consisting of a cylinder of gas, a regulator, a gage expansion tank and a conducting tube, having a nozzle with a valve operated by thumb pressure.

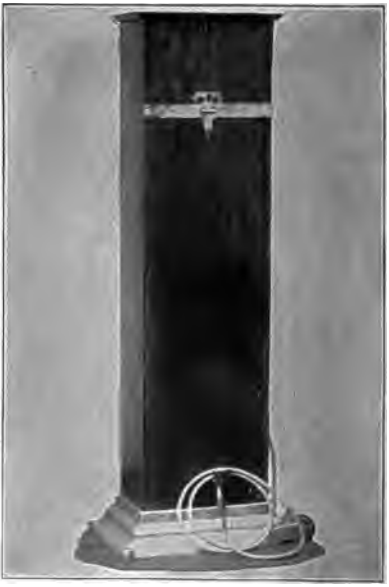


Fig. 101. Tire Inflating Cabinet (Closed).

The accompanying illustrations (Figs. 101 and 102) show the case opened and closed.

When a tire is to be inflated, it is put in position; the thumb gently presses the release valve, and the tire is automatically filled with gas. When the tire is fully inflated, the valve is closed, and the tire ready for use.

This method of inflating tires has been much in vogue in France, but a French scientist, Arsonval, is said to have demonstrated that carbonic acid gas under more than eighty pounds pressure passes through rubber by degrees, while at the same time causing the rubber to swell and lose part of its elasticity, though not permanently injuring it, as it resumes its size, appearance and usual properties when the pressure of carbonic acid gas is removed.

The principle of the differential gear ordinarily used in automobiles of all types, to permit one of two wheels driven by the same motor to revolve faster than the other, is illustrated in Fig. 103, part of the driving axle and one wheel being shown. The axle is double, one part within the other, A and B, each divided into two parts. The outer part does not revolve, but carries the driven axle in ball-bearings as shown. The inner ends of the outer axle are connected with the casing of the differential gear c, affording a support to its revolving members, making a dust and waterproof covering, also a receptacle for oil for lubrication, and for the ball-bearing for the differential gear. The outer ends of this axle cover the ball-bearings d, connecting with the hubs of the wheels. By referring to the figure again, the reader will notice a shaft, e, at right angle to the axle. This connects with the motor, and engages the differential gear with a beveled pinion. As the power

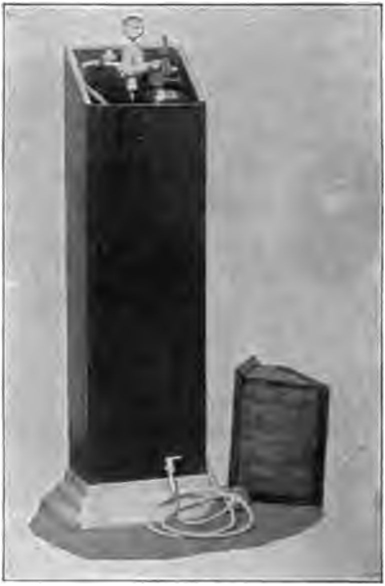


Fig. 102. Tire Inflating Cabinet (Open).

to be transmitted is to be delivered at a right angle from its source, it is accomplished by the beveled gear f.

Let us suppose the vehicle is moving forward; both wheels are driving at the same time; by changing the direction from right to left the outside wheel is made to travel faster than the inner one. This would not be the case if the differential gear were omitted. It is obtained by placing two bevel gears, g, near each inner end of the driving shaft. At right angles to this shaft is a short shaft, h, its ends held in bearings, which form a part of the casing. Its center forms a block, i, or bearing, in which the inner ends of the driving shaft are held. On this shaft, between the block and its outer end, are shown two beveled gears, j, which engage with the two beveled gears on the driving shaft. When this shaft revolves with the vehicle moving forward, both halves revolve at the same speed; but if turned to the right, the left half will turn faster; if turned to the left, the right half will turn faster. The action is reversed when the direction of the vehicle is reversed.

The axle bearings in automobiles are not necessarily different in principle from those employed in ordinary vehicles loaded to the same weight and intended for the same speed, but as the automobiles are throughout modern in other respects, it is natural that the makers strive to design also the axle bearings and other bearings in the vehicle on the most approved modern lines.

The weight and intended speed of automobiles being invariably in excess of the weight and speed of the corresponding patterns of horse-drawn vehicles, makes it necessary that greater care should be given to the design and material of their bearings, and this requirement is further emphasized by the rattling noise which would be caused in automobiles by poor bearings by reason of the extensive employment of metal in the automobile frames.

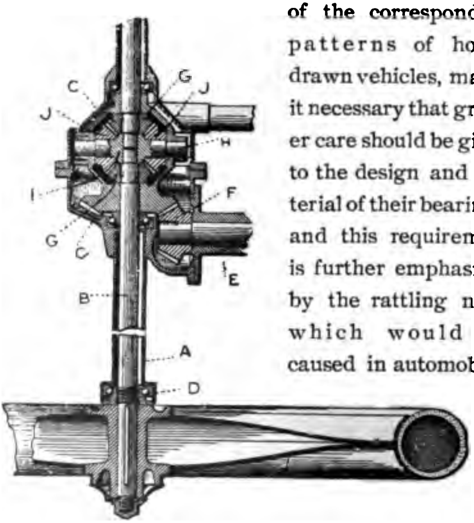


Fig. 103. Type of Differential Gear.

With reference to motor bearings it is to be noted that the same severity in requirements prevails. They may be compared to bearings in other machinery operated at high speed, but while other machinery is usually either stationary or intended for transportation over smooth steel rails, the motor bearings in automobiles are to be shaken and jolted over all kinds of roads. In order to be noiseless and smooth-running, they must, therefore, be of the very best design and workmanship, and must be adapted to work well under end-pressure, even if normally horizontal, because an automobile in action may assume different angles varying from the normal level.

It follows from the compactness of automobile construction and the demand for a pleasing design, that many bearings in automobiles are less readily accessible than similar bearings in vehicles or stationary machinery; and for this reason also is it of great importance that each bearing be designed mechanically correct, so as to reduce wear to a minimum and give as little occasion as possible for readjustments, lubrication and repairs.

It will be seen that despite the numerous thrifty reasons why bearings for automobiles must be made with extraordinary care and skill, there is really nothing in the principle of automobile bearings to distinguish them from machine and vehicle bearings in general; and as the subject of bearings in general is a large one, which could not be profitably discussed in a few pages, the reader who wishes to enter into it in detail is referred to the illustrated treatises on ball and roller bearings of various types which are published by manufacturers.

The main trouble with ball-bearings similar to those in bicycles is the liability to crushing one or more balls under the heavy loads of automobiles, and destroying the whole bearing before the accident is discovered. This is obviated to some extent by using ball-bearings in which each ball has four points of contact with the other bearing members; but such four-point bearings, if inaccurately made or ineptly designed, are worse than common two or three point bearings.

With roller bearings it has been found difficult to confine the rollers to a straight course and prevent them from wedging. But great progress has been made lately in this respect, under the stimulus of the extraordinarily severe requirements for automobile construction.

Part VI

Rules and Regulations Concerning the Operating of Automobiles

CHAPTER XX

CHICAGO CITY ORDINANCE

Section 1. No automobile, autocar, or other similar vehicle shall be propelled or driven upon or along any street, alley or other public way in the City of Chicago unless the person in charge or control of such vehicle, and who is acting as the operator thereof, and as such operator controls the means of propulsion of any such automobile, autocar or other similar vehicle, shall be a person duly licensed by the City of Chicago to act as an operator of such vehicles in the manner hereinafter provided; and for the purposes of this ordinance the terms or names "Automobile," "Autocar," and "other similar vehicles," wherever and whenever used in this ordinance, shall be held to embrace and mean, and are hereby defined to mean, any vehicle driven or propelled upon or along the streets, alleys or other public ways of this city, whether for purposes of business or pleasure, or for both, the motive power of which is electricity, compressed air, naphtha, gasoline, kerosene, or any other motive power other than animal power or motive power supplied solely by exertion of a human being. Provided, however, that nothing herein shall apply to the operation of any locomotive, grip-car, motor, trolley-car, or other vehicle used by any steam or street railway upon and along any track or tracks owned or authoritatively used by any steam or street railway company or corporation.

Section 2. The Mayor shall appoint a Board of Examiners, consisting of three persons, one of whom shall be the City Electrician, one the Commissioner of Health, and one the City Engineer; and it shall be the duty of such Board of Examiners, when appointed, to examine into the qualifications, ability and capacity of any person or persons who may desire to obtain a license or certificate of qualification to operate any such automobile, autocar, or other similar vehicle; and such Board of Examiners shall be officially known and described as the "Board of Examiners of Operators of Automobiles." The said Board of Examiners shall have the power and authority, and it is hereby made its duty, to examine into the qualifications and fitness of any applicant for a license or certificate of qualification to act as an operator under the provisions of this ordinance; and to carry out the purposes of this ordinance the said Board may make such rules and regulations as may be deemed by it expedient or necessary for the purpose of determining the fitness of any applicant for a license or certificate of qualification hereunder. And the said Board of Examiners shall hold examinations as often as may be deemed necessary, setting apart, however, no fewer than two days per month for such examinations, and such examinations shall be conducted with a view to ascertaining the physical ability, mental qualifications and possession by the applicant of a sufficient amount of mechanical knowledge and ability to understand the working parts of the mechanism or apparatus used for propelling or driving any such automobile, autocar or other similar vehicle.

Section 3. Every application for a license or certificate of qualification hereunder shall be made upon a printed form furnished by the said Board of Examiners, and shall set forth the name, age, citizenship and occupation of such applicant. Any applicant who shall have been examined by the said Board of Examiners and deemed by it capable of acting as an operator as herein provided, shall have issued to him or her a certificate of qualification, or license, authorizing the person so examined and found capable, to act as an "automobile operator," and each such license or certificate so issued shall expire one year from the date of issue.

Section 4. The fee for such license or certificate of qualification shall be three ($3.00) dollars for the first year, and upon the expiration of any such certificate or license, the holder thereof shall be entitled to a renewal of such certificate or license each year thereafter, without further examination, upon the payment of a fee of one ($1.00) dollar for each such renewal.

Section 5. Every license or certificate of qualification issued by the said Board of Examiners shall be signed by all or a majority of said Board and shall bear an imprint of the said Board's seal. Any member of said Board shall have the power and authority to temporarily revoke any license or certificate of qualification issued by said Board upon a finding that the person holding any such license or certificate has proved unfit to act as an operator, either by reason of carelessness, intemperance, or by reason of any other cause deemed sufficient by the said Board to require a revocation of such license or certificate. Provided, however, that no person shall have his or her certificate or license finally revoked without first being given an opportunity to be heard by the said Board of Examiners in his or her defense. Such revocation may be made for a limited period or permanently, as the said Board may determine, and in case of the revocation of any such license or certificate the fee paid therefor shall be forfeited to the city.

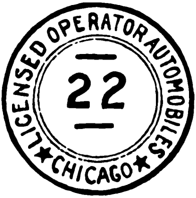
Section 6. The Board of Examiners herein provided for shall cause to be kept a full and correct record of its official proceedings, including the names of the members of the said Board, the name, age and residence of each applicant for a license or certificate, the number of certificates issued or rejected, the number of certificates renewed or revoked and the cause of such revocation, together with the name of the person whose license or certificate was revoked. Also, the amount of money received or expended, and the said Board shall cause a full financial report to be made each month, and shall file the same not later than the 15th day of each and every month with the City Comptroller.

Section 7. The Mayor shall designate and set apart any room or rooms in the City Hall for the use of said Board of Examiners he may see fit, and shall also appoint or designate some employe in the classified clerical service of the city to act as Secretary to the said Board of Examiners, and the said Secretary, when so appointed or designated, shall perform such duties as he may be directed to perform from time to time by the said Board of Examiners or any member thereof, and the members of the said Board of Examiners and the Secretary thereof shall perform all the duties herein provided for without further compensation than that paid them or either of them in their respective offices or positions under the municipal government. Until the next annual appropriation shall have been made, the expense necessary to be incurred by the said Board of Examiners in following out the provisions of this ordinance shall be paid from the receipts of such Board of Examiners under this ordinance, and a full report of such expenditure shall be made to the City Comptroller with each monthly financial report made as hereinbefore provided.

Section 8. No automobile, autocar or other similar vehicle shall be propelled or driven upon or along any street, alley or public way of the City of Chicago, at a speed exceeding eight (8) miles per hour, and such vehicles when in motion must be kept to the right, and shall observe the rule of the road as laid down for all other vehicles.

Section 9. Each and every automobile, autocar or other similar vehicle driven or propelled upon or along any street, alley or public way in the City of Chicago shall be equipped and supplied with an alarm bell or gong of not less than four inches in diameter, and the same shall be sounded at street crossings and wherever else deemed advisable by the operator of such vehicle, to be sounded for the purpose of notifying pedestrians or others of the approach of any such vehicle, and each automobile, autocar or other similar vehicle shall be equipped with a brake or set of brakes, which shall be of sufficient power when applied to bring any such vehicle, when at a speed of eight miles an hour, to a full stop within ten feet from the point such vehicle was when such brake was applied, and all such vehicles shall carry a lighted lamp, or lamps, in a conspicuous position on such vehicle whenever in motion on any street, alley or other public way at any time after dusk and before dawn.

Section 10. No person shall operate, drive or propel any automobile, autocar or other similar vehicle upon or along any street, alley or other public way in the City of Chicago without having first obtained a certificate of qualification so to do, as hereinbefore provided, and any person violating any of the provisions of this ordinance shall, upon conviction thereof, be fined not less than $5.00 nor more than $25.00 for each offense.



Model of Badge to be Worn by All Operators
(Male or Female).

CHAPTER XXI

THE NEW YORK CITY ORDINANCE

Section 1. On and after December 31, 1899, no horseless wagon, automobile, or any other vehicle operated by electricity, compressed air or any other motor power on the surfaces of the streets of The City of New York, save and excepting street surface railroad cars, shall be run, conducted or operated, unless by an individual duly licensed to run, conduct or operate the same; and no such individual shall be declared fit to conduct, propel, run or operate such horseless wagon, automobile or other vehicle so operated, unless he shall have submitted to the Chief of the Bureau of Licenses of The City of New York sufficient proof of his fitness to justify such Chief in granting him a license.

Section 2. The owner of each and every such wagon, automobile or other horseless vehicle shall pay to The City of New York a similar license fee to that now paid by the owners of cabs.

Section 3. No such wagon, automobile or other horseless vehicle shall be driven, run, propelled or operated through the streets and avenues of The City of New York at a greater rate of speed than that of five miles an hour; and each and every such wagon, automobile or other horseless vehicle shall have a bell loud enough to be heard at a distance of five hundred feet, and said bell shall be used to warn vehicles or pedestrians of the approach of said wagons, automobiles or other horseless vehicles.

Section 4. All ordinances or parts of ordinances inconsistent or conflicting with the provisions of this ordinance are hereby repealed.

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THE NEW YORK CITY ORDINANCE

Section 1. On and after December 31, 1899, no horseless wagon, automobile, or any other vehicle operated by electricity, compressed air or any other motor power on the surfaces of the streets of The City of New York, save and excepting street surface railroad cars, shall be run, conducted or operated, unless by an individual duly licensed to run, conduct or operate the same; and no such individual shall be declared fit to conduct, propel, run or operate such horseless wagon, automobile or other vehicle so operated, unless he shall have submitted to the Chief of the Bureau of Licenses of The City of New York sufficient proof of his fitness to justify such Chief in granting him a license.

Section 2. The owner of each and every such wagon, automobile or other horseless vehicle shall pay to The City of New York a similar license fee to that now paid by the owners of cabs.

Section 3. No such wagon, automobile or other horseless vehicle shall be driven, run, propelled or operated through the streets and avenues of The City of New York at a greater rate of speed than that of five miles an hour; and each and every such wagon, automobile or other horseless vehicle shall

DON'TS

DON'T—

Attempt to run an automobile without a a license, if such an ordinance is in force in your city.

DON'T—

Fail to observe the "rules of the road." Always keep to the right. If you desire to precede any vehicle in front of you, pass to the left, after ringing your bell, or sounding your horn, as your equipment may permit.

DON'T—

Fail to keep your lamps in a condition that will permit of instant use. This is of great importance.

DON'T—

Attempt to improve the operation of your machine by readjusting it. No self-respecting manufacturer will deliver you a vehicle until it has been thoroughly tested.

DON'T—

Fail to have your tires cleaned after using them, as this attention will prolong their life. If they are pneumatic, keep them pumped up hard all the time.

DON'T—

Fail to examine the ball, or roller-bearing axles at least once in three months. Wipe them off carefully, then wash them with gasoline; afterwards rub them with vaseline, so as not to make them sticky, and finally readjust the parts with great care.

DON'T—

Fail to keep in their proper place such tools as manufacturers provide with each vehicle; you may have to use them in an emergency.

DON'T—

Attempt any but *first* speed, until you have learned to judge distances and the rates of speed your machine will travel. Bicycle riders quickly learn this. You must learn the speed of your vehicle under all conditions. You cannot, as on a bicycle, tell by the amount of power you are exerting what your rate of speed is.

DON'T—

Fail to observe the special rules laid down by each manufacturer.

THE AUTOMOBILE LOG

Log of the Automobile ______________________________

owned by ______________________________

in charge of ______________________________

while on a journey from ______________________________

to ______________________________

Time of departure ______ *date* ______________

State of Roads ______________________________

Weather ______________________________

No. of Persons on board ______________________________

			lbs.
Weight of Persons on board	..	..	
" *Fuel* "	..	..	
" *Supplies* "	..	..	
" *Baggage* "	..	..	
Total Weight ..	..	..	